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RESEARCH PAPER

# Microbiological analysis on the environmental hygiene for galley equipment, safety equipment and cabin common facilities of a local airline in Malaysia

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## Abstract

Academic literatures with regard to environmental hygiene in the aviation industry are very limited and have not received laborious research. This condition produced a vacuum of knowledge that has been long overdue. As such, this study presented an opportunity with the aim to determine the environmental hygiene of airplanes operated by a local airline in Malaysia. Ninety nine swab samples (n=99) were collected from four distinctive medium haul inbound flight sectors into Kuala Lumpur International Airport, Malaysia. Two of the airports were that of the developing countries of India and Bangladesh and the other two airports were selected from a developed countries of Japan and Australia. These samples were analyzed using conventional microbiological aerobic mesophilic plate count. The findings revealed that the environmental hygiene of the galley equipment (GE), safety equipment (SE) and cabin common facilities (CF) showed a low prevalence of bacterial contamination where 24 (4.4%), 4 (4.04%) and 6 (6.06%) samples were reported, respectively. The report concluded that 69 (67.7%) samples fell within the good level of hygiene where the colony counts were <20 mL/ CFU and 12 (12.12%) samples were reported as having acceptable level of hygiene where the colony counts fell within 21 to 100 CFU/mL. However, 18 (18.2%) samples indicated to have unacceptable level of hygiene with colony counts more than 100 CFU/mL. These results sugggested that the prevalence of the bacteria does not depend as to whether the country is developing or already a developed nation. Even though Bangaluru and Dhaka are both airports of developing countires yet the number of contaminated samples were reported at 20 and 3 samples, respectively. Whereas airports of developed countries of Sydney and Narita produced 8 and 3 contaminated samples, respectively. More importantly, as frontliners who handled the GE, SE and, CF interchangeably, continuous awareness programs highlighting effective housekeeping and good personal hygiene behaviors among the flight attendants are imperative.

## 1. Introduction

One of the main challenges in conducting scientific research in the aviation environment is that this field is not easily accessible. Like most business organizations, the element of time is a very fluid constraint upon which the profit and loss of the operator are formulated. In such study as conducting environmental microbiological analysis, specific authorization may also be required to collect relevance samplings for analysis. In the effort to determine the environmental hygiene, three categories which included galley equipment, safety equipment and cabin common facilities were selected. These areas are frequently utilized by flight attendants within the course of handling and serving of food onboard the airplane. The in-flight food production chain from the catering to the consumers' dining table as reckoned by HACCP management system involves a lengthy processes. This production process is undoubtedly exposed airlines foods to high potential of direct contamination and other cross contamination risk factors. Potential adulterated

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Table 1. Microbiologocal environmental hygiene results for galley equipment, safety equipment and cabin common facilities.

| | Flight sectors | | | | | |
|---|---|---|---|---|---|---|
| | DAC/KUL | SYD/KUL | NRT/KUL | BLR/KUL | Total (%) | |
| | Medium haul n=23 | Medium haul n=23 | Medium haul n=23 | Medium haul n=30 | N=99 | |
| Prevalence | 3 | 8 | 3 | 20 | 34 | |
| ND | 20 | 15 | 20 | 10 | 65 | |
| Colony count | | | | | Description of Hygiene Levels (%) | |
| TPC <20 CFU/mL | 20 | 15 | 20 | 14 | 69 | Good (69.7%) |
| TPC 20-100 CFU/mL | 1 | 7 | 1 | 3 | 12 | Acceptable (12.12%) |
| TPC >100 CFU/mL | 2 | 1 | 2 | 13 | 18 | Not acceptable (18.2%) |
| Galley equipment | 2 | 1 | 1 | 20 | 24 | 24.24% |
| Safety equipment | 1 | 3 | 0 | 0 | 4 | 4.04% |
| Cabin common facilities | 0 | 4 | 2 | 0 | 6 | 6.06% |
| Total | 3 | 8 | 3 | 20 | 34 | 34.34% |

Note:
The colony count and description of hygiene were adapted from Hygiene level is based on Environmental Hygiene Monitoring: A Guide for Environmental Health Officers, 2010, BC Center for Disease Control, Provincial Health Services Authority.
ND, Not detected

conditions such as transit time, holding time, temperature, climate change and final food handlers (flight attendants), serve as potential sources of food contamination.

Foodborne illnesses and diseases are in most cases originated from venerable microorganisms. Foodborne diseases have been associated with microorganisms like bacteria, fungi, viruses and parasites (Mutalib *et al*., 2015). Lorenzo and his fellow researchers recognized that there are several groups of microorganisms that are critical to food safety; bacteria, molds, yeast, virus and parasites (Lorenzo *et al*., 2018). Bacteria may come in several forms and shapes that commonly referred to as cocci, rod-shaped and spiral-shaped. According to Su *et al.* (2015) bacterial contamination in foods is one of the most crucial sources of foodborne related diseases. Consumption of contaminated and cross-contaminated food can cause a foodborne outbreak especially to those of weak immune system such as the elderly, infants, children and immune-compromised individuals (Kennedy *et al.,* 2004). Research conducted by Kendall *et al*. (2003) identified 13 pathogens that are proned to the food handling behaviors among pregnant women, infants, young children, the elderly and those with immune-compromised people.

Taking into account the potential risk of food adulteration caused by bacterial contamination and the other constraints that governed by regulatory bodies, this study was a novel attempt on such setting in the Malaysian aviation industry. Capturing awareness and highlighting the importance of environmental hygiene, which include food premises hygiene and good sanitations associated to the food handling hygiene and food handling practices, are concerns that we cannot afford to neglect (Mutalib *et al.,* 2015). Therefore, the objective of this microbiological analysis was to determine the hygiene levels via surfaces swab samplings using the conventional microbiological analysis method.

Table 2. Airplanes galley equipment, safety equipment and the common facilities categories.

| | Type of flight sector | | Number of swab samples | | | |
|---|---|---|---|---|---|---|
| | | | Medium haul flight | Medium haul flight | Medium haul flight | Medium haul flight |
| | | Sector | DAC/KUL | SYD/KUL | NRT/KUL | BLR/KUL |
| No | Items identification | Category | | | | |
| 1 | Latches | | 2 | 4 | | 17 |
| 2 | Ovens | | 2 | 4 | | 4 |
| 4 | Wine Chillers | | 3 | | | |
| 5 | Galley Worktops | Galley Equipment GE = 53 | 2 | | | |
| 6 | Water Boiler Faucets | | | | | 3 |
| 7 | Meal Cart Handles | | | | | 4 |
| 8 | Meal Cart top | | | | 6 | |
| 9 | Document Clips | | | | | 2 |
| 10 | Lavatories | Cabin Facilities CF=25 | 5 | 10 | 10 | |
| 11 | Crew Seatbelts | Safety Equipment SE = 21 | 5 | | 3 | |
| 12 | Crew Bunks | | | | 2 | |
| 13 | Door Handles | | | 5 | | |
| 14 | Handsets | | 4 | | 2 | |
| | Total | | 23 | 23 | 23 | 30 |
| | Cumulative Total | | | 99 | | |

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Table 3. The type of flight sectors, aircraft types and sector of origins of the international inbound medium haul flight sectors selected for microbial analysis.

| Range/haul | Country of origin | Sector | Aircraft type | Flight type |
|---|---|---|---|---|
| Medium | Bangladesh | DAC/KUL | A330-200 | International |
| Medium | Australia | SYD/KUL | A330-300 | International |
| Medium | Japan | NRT/KUL | A380-900 | International |
| Medium | India | BLR/KUL | A330-200 | International |

## 2. Materials and methods

### *2.1 Samples*

In reference to the Table 1, ninety nine swab samples were collected from four selected inbound medium haul flight sectors as indicated in Table 3, in accordance to the aircraft types and scheduled flight times. Four microorganisms were selected and enumerated as hygiene indicators which include, *Escherichia coli*, *Vibrio*, *Salmonella* and coliforms. These swab samples were also taken from three category of airplanes equipment and common facilities. Table 3 mentioned the first category was the galley equipment and secondly was the safety equipment category and the third category was referred to as common cabin facilities.

Four inbound flight sectors into Kuala Lumpur International Airport, KLIA, were selected for swab samples collection. These flight sectors were all medium range that flew into KLIA with flight time less than eight hours. The first inbound sector was travelled from Dhaka, India on an Airbus A330-200. The second swab samplings collection were taken from an inbound sector flew from Sydney, Australia operated by using Airbus A330-300 and the third swab samplings were taken from Narita, Japan. The flight from Narita Japan was operated by the super jumbo, Airbus A380-900 and the fourth inbound sector was originated from Bengaluru, Bangladesh operated by an Airbus A330-200. The summary of the inbound flight sectors is illustrated in Table 2.

Upon arrival at Kuala Lumpur International Airport, the swab samples were immediately transported to the Food Safety and Quality Laboratory at Food Science and Technology faculty, UPM Serdang. Each cotton swab was placed individually in a small sterile zip-type transparent polyethylene plastic bag, 30 mm × 60 mm. All of the individually packed swab samples were kept cool in another large sterile double zipper polyethylene transparent plastic bag, 144 mm x 160 mm. The large sterile plastic bag were placed in a mini cooler bag and transported to the laboratory within 4 h upon arrival of airplanes at Kuala Lumpur International Airport.

### *2.2 Microbiological analysis of samples*

Standard preparation protocols as recommended by Beuchat and Cousin (2001), Karnacki and Johnson (2001), Morton (2001), were followed 9 mL of the peptone water broth (Oxoid$^{TM}$ Basingstoke, Hampshire, UK) was autoclaved at 121˚C for 15 minutes before the 9 mL suspended into standard universal bottles accordingly. Selected agars were prepared following manufaturer's instruction. EMBA (Eosin Methylene Blue Agar) to detect the presence of *E. coli.* Chrom*Salmonella*, Chrom*Vibrio* were use to detect the presence of *Salmonella and Vibrio,* respectively. These selected agars, EMBA, Chrom*Salmonella*, Chrom*Vibrio* and coliform, were heated to boiling points to dissolve the medium. After cooling down poured into the respective petri dish plates. The cotton swab samples were cut at both ends and placed into the 10 mL universal bottles, briskly shaken, and incubated at 37˚C for 24 h. The incubated samples were then streaked onto respective agar plates and incubated at 37˚C for another 24 h. The plate counts were performed upon completion of the incubation cycle.

### *2.3 Flight sectors selection*

Four international inbound flight sectors into Kuala Lumpur International Airport, KLIA, were selected for swab samples collection. These flight sectors were all medium range that flew into KLIA with flight time less than eight hours. The first inbound sector was travelled from Dhaka, India on an Airbus A330-200. The second swab samplings collection were taken from an inbound sector flew from Sydney, Australia operated by using Airbus A330-300 and the third swab samplings were taken from Narita, Japan. The flight from Narita Japan was operated by the super jumbo, Airbus A380-900 and the fourth inbound sector was originated from Bengaluru, Bangladesh operated by an Airbus A330-200. The summary of the inbound flight sectors is illustrated in Table 3.

### *2.4 Quantitative analysis results and hygiene standard limits*

After the incubation period of 48 h, the aerobic mesophilic agar plates were inspected for microbial growth as per the selective microorganism indicators. The standard protocol of spread plate method as recommended by Beuchat and Cousin (2001), Karnacki and Johnson (2001), Morton (2001), were adhered to so that the slow growth of the bacterial colonies may be visible and the total plate count can be taken after the incubation period (Tortora *et al.*, 2003). *Escherichia coli, Vibrio, Salmonella* and coliforms were used for this study because they are commonly selected as microorganism indicators to determine the hygiene level

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Table 4. Plate count results for 23 swab samples taken from aircraft galley equipment, safety equipment and cabin common facilities of a medium haul sector DAC/KUL, with an Airbus A330-200 travelled on 8th August 2018.

| NO | Date for Analysis | Location Identification | Equipment Category GE, CF, SE | *E. coli* CFU/ mL | *Vibrio* CFU/mL | *Salmonella* CFU/mL | Coliforms CFU/mL |
|---|---|---|---|---|---|---|---|
| 1 | 10/8/2018 | Lavatory D1L | CF | ND | ND | ND | ND |
| 2 | 10/8/2018 | Lavatory D2R | CF | ND | ND | ND | ND |
| 3 | 10/8/2018 | Lavatory D3L | CF | ND | ND | ND | ND |
| 4 | 10/8/2018 | Lavatory D3R | CF | ND | ND | ND | ND |
| 5 | 10/8/2018 | Lavatory D4R | CF | ND | ND | ND | ND |
| 6 | 10/8/2018 | Closet C202 Latch | GE | ND | ND | ND | ND |
| 7 | 10/8/2018 | Closet CRR Latch | GE | ND | ND | ND | ND |
| 8 | 10/8/2018 | Dry Galley 2 Worktop | GE | ND | ND | ND | ND |
| 9 | 10/8/2018 | Oven 121 Knob | GE | ND | ND | ND | ND |
| 10 | 10/8/2018 | Oven 122 Knob | GE | ND | ND | ND | ND |
| 11 | 10/8/2018 | Wet Galley 1 Worktop | GE | ND | ND | ND | ND |
| 12 | 10/8/2018 | Wine Chiller Knob Galley 1 | GE | ND | ND | ND | ND |
| 13 | 10/8/2018 | Wine Chiller Knob Galley 2 | GE | ND | ND | ND | 71 |
| 14 | 10/8/2018 | Wine Chiller Knob Galley 4 | GE | ND | ND | ND | 114 |
| 15 | 10/8/2018 | Crew Seatbelt D1L(A) | SE | ND | ND | ND | ND |
| 16 | 10/8/2018 | Crew Seatbelt D1L(P) | SE | ND | ND | ND | ND |
| 17 | 10/8/2018 | Crew Seatbelt D1R | SE | ND | ND | ND | ND |
| 18 | 10/8/2018 | Crew Seatbelt D2L | SE | ND | ND | ND | ND |
| 19 | 10/8/2018 | Crew Seatbelt D2R | SE | ND | ND | ND | ND |
| 20 | 10/8/2018 | Handset Door 1 Left | SE | ND | ND | ND | ND |
| 21 | 10/8/2018 | Handset Door 2 Left | SE | ND | 105 | ND | ND |
| 22 | 10/8/2018 | Handset Door 2 Right | SE | ND | ND | ND | ND |
| 23 | 10/8/2018 | Handset Door1 Right | SE | ND | ND | ND | ND |

Note:
CF, common facilities, i.e. lavatories
GE, Galley equipment
SE, Safety equipment
ND, Not detected
DAC, Dhaka
KUL, Kuala Lumpur

and contamination of food samples in food safety. The hygiene standard as stipulated in the Environmental Hygiene Monitoring: A Guide for Environmental Health Officers (2010) denotes that a contact plate CFU/g of <20 is described as good. Whereas a count that falls within 21-100 CFU/g is denoted as acceptable. Any plate count that is >100 CFU/g is considered as not acceptable. These counts are based on 10 $cm^2$ surface area sampled. The enumeration and detection of these microbial indicators on the surface swabs samples indicate the hygiene level of the areas of concerned. The overall microbiological results and the standard limits descriptions of all selected galley equipment, safety equipment and common facilities are summarized in Table 1.

## 3. Results and data analysis

### *3.1 Enumeration and detection of Escherichia coli, Vibrio, Salmonella and coliforms on galley equipment, safety equipment samples taken from Dhaka to Kuala Lumpu flight sector*

The first microbial analysis using the conventional method was conducted for the inbound sector, originating from Hazrat Shahjalal International Airport, Dhaka (DAC) Bangladesh. There were 23 swab samples collected and the microbiological workload was completed on 10th August 2018 (Table 4). Five cabin common facilities, 9 galley equipment, and 9 safety equipment were analyzed for enumeration and detection of microbial colony count. It was reported that only 3 samples were detected with the selected microorganism indicators. Table 4 showed two galley equipment which included the Wine Chiller Knob at Galley 2 and Wine Chiller Knob at Galley 4 were contaminated by coliforms with an average microbial load that fell within the acceptable level of hygiene with an average of 92.5 CFU/mL. *Vibrio* was detected in one safety equipment, Handset Door 2L, which had a colony count of 105 CFU/mL, which fell in the not acceptable level of hygiene. Remarkably, Table 4 shows that *E. coli* and *Salmonella* were not detected in all of the samples. It was concluded that the hygiene level for this sector was at a good and acceptable level with 20 and 1 samples, respectively. However, 2 samples had bacterial counts above the unacceptable threshold of more than 100 CFU/ mL. *Escherichia coli* and *Salmonella* were not detected in all samples.

### *3.2 Enumeration and detection Escherichia coli, Vibrio, Salmonella and coliforms on galley equipment, safety equipment samples taken from Sydney to Kuala Lumpur flight sector*

The second microbiological analysis consisted of another 23 swab samples collected from inbound flights originating from Sydney (SYD), Sydney Kingsford Smith International Airport, New South Wales, Australia. Eleven cabin common facilities, 6 galley equipment, and 6 safety equipment were analyzed for enumeration and detection of the microbial colonies. It was reported that 15 samples did not show any bacterial contamination which was concluded as falling in the good level of hygiene. Seven samples were reported to have shown bacterial count that fell in the good hygiene level of between 21 to 100 CFU/mL bacterial counts.

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Table 5. Plate count results for 23 swab samples taken from aircraft galley equipment, safety equipment and cabin common facilities of a medium haul sector SYD/KUL, with an Airbus A330-300 travelled on 8th August 2018.

| NO | Date for Analysis | Location Identification | Equipment Category GE, CF, SE | *E. coli* CFU/mL | *Vibrio* CFU/mL | *Salmonella* CFU/mL | Coliforms CFU/mL |
|---|---|---|---|---|---|---|---|
| 1 | 10/8/2018 | Closet Door 1R | CF | ND | ND | ND | ND |
| 2 | 10/8/2018 | Lavatory 1L Flush | CF | ND | ND | ND | ND |
| 3 | 10/8/2018 | Lavatory 2R Flush | CF | ND | ND | ND | ND |
| 4 | 10/8/2018 | Lavatory 3L Flush | CF | ND | 4 | ND | 52 |
| 5 | 10/8/2018 | Lavatory 3LC Flush | CF | ND | ND | ND | ND |
| 6 | 10/8/2018 | Lavatory 3RC Door Latch | CF | ND | 67 | ND | ND |
| 7 | 10/8/2018 | Lavatory 3RC Flush | CF | ND | ND | ND | 238 |
| 8 | 10/8/2018 | Lavatory 3RR Door Latch | CF | 20 | ND | 136 | 112 |
| 9 | 10/8/2018 | Lavatory 3RR Flush | CF | ND | ND | ND | ND |
| 10 | 10/8/2018 | Lavatory Shelf 3RC | CF | ND | ND | ND | ND |
| 11 | 10/8/2018 | Lavatory Shelf 3RR | CF | ND | ND | ND | ND |
| 12 | 10/8/2018 | Galley 1 Latch 2 | GE | ND | ND | ND | ND |
| 13 | 10/8/2018 | Galley1 Latch1 | GE | ND | ND | ND | ND |
| 14 | 10/8/2018 | Oven Timer Galley 11 | GE | ND | ND | ND | ND |
| 15 | 10/8/2018 | Oven Timer Galley 12 | GE | ND | ND | ND | ND |
| 16 | 10/8/2018 | Oven Timer Galley 21 | GE | ND | ND | ND | 14 |
| 17 | 10/8/2018 | Oven Timer Galley 22 | GE | ND | ND | ND | ND |
| 18 | 10/8/2018 | Assist Door Handle 2R | SE | ND | ND | ND | ND |
| 19 | 10/8/2018 | Assist Door Handle 4L | SE | ND | ND | ND | 60 |
| 20 | 10/8/2018 | Crew seatbelt 1R | SE | ND | ND | ND | 29 |
| 21 | 10/8/2018 | Door Assist Handle 1R | SE | ND | ND | ND | ND |
| 22 | 10/8/2018 | Door Handle 1R | SE | ND | ND | ND | ND |
| 23 | 10/8/2018 | Handset Door 1R | SE | ND | ND | ND | 79 |

Note:
CF, common facilities, i.e. lavatories
GE, Galley equipment
SE, Safety equipment
ND, Not detected
SYD, Sydney
KUL, Kuala Lumpur

Table 6. Plate count results for 23 swab samples taken from aircraft galley equipment, safety equipment and cabin common facilities of a medium haul sector NRT/KUL, with an Airbus A350-900 travelled on 28th August 2018.

| NO | Date for Analysis | Location Identification | Equipment Categor GE, CF, SE | *E. coli* CFU/mL | *Vibrio* CFU/mL | *Salmonella* CFU/mL | Coliforms CFU/mL |
|---|---|---|---|---|---|---|---|
| 1 | 30/8/2018 | Lavatory 3LL Door Latch | CF | ND | ND | ND | ND |
| 2 | 30/8/2018 | Lavatory 3LL Flush Switch | CF | ND | ND | 1 | 76 |
| 3 | 30/8/2018 | Lavatory 3LL Diaper Shelf | CF | ND | ND | ND | ND |
| 4 | 30/8/2018 | Lavatory 3CR Door Latch | CF | ND | ND | ND | ND |
| 5 | 30/8/2018 | Lavatory 3CR Flush Switch | CF | ND | ND | ND | 123 |
| 6 | 30/8/2018 | Lavatory 3RR Diaper Shelf | CF | ND | ND | ND | ND |
| 7 | 30/8/2018 | Lavatory 3LR Door Latch | CF | ND | ND | ND | ND |
| 8 | 30/8/2018 | Lavatory 3LR Flush Switch | CF | ND | ND | ND | ND |
| 9 | 30/8/2018 | Lavatory 3CR Door Latch | CF | ND | ND | ND | ND |
| 10 | 30/8/2018 | Lavatory 3CR Flush Switch | CF | ND | ND | ND | ND |
| 11 | 30/8/2018 | Meal Cart Top 1 | GE | ND | ND | ND | ND |
| 12 | 30/8/2018 | Meal Cart Top 2 | GE | ND | ND | ND | ND |
| 13 | 30/8/2018 | Meal Cart Top 3 | GE | ND | ND | ND | ND |
| 14 | 30/8/2018 | Meal Cart Top 4 | GE | ND | ND | ND | ND |
| 15 | 30/8/2018 | Meal Cart Top 5 | GE | ND | ND | ND | ND |
| 16 | 30/8/2018 | Meal Cart Top 6 | GE | 151 | ND | 186 | 219 |
| 17 | 30/8/2018 | CABED | SE | ND | ND | ND | ND |
| 18 | 30/8/2018 | Crew Bunk Door Knob | SE | ND | ND | ND | ND |
| 19 | 30/8/2018 | Handset D4L | SE | ND | ND | ND | ND |
| 20 | 30/8/2018 | Handset D4R | SE | ND | ND | ND | ND |
| 21 | 30/8/2018 | Crew seatbelt D3L | SE | ND | ND | ND | ND |
| 22 | 30/8/2018 | Crew seatbelt D4L | SE | ND | ND | ND | ND |
| 23 | 30/8/2018 | Crew seatbelt D4R | SE | ND | ND | ND | ND |

Note:
CF, common facilities, i.e. lavatories
GE, Galley equipment
SE, Safety equipment
ND, Not detected
NRT, Narita-Tokyo
KUL, Kuala Lumpur

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Table 7. Plate count results for 30 swab samples taken from of airplane galley equipment, safety equipment and cabin common facilities of a medium haul sector BLR/KUL, on an Airbus A330-200 travelled on 15th October 2018.

| NO | Date for Analysis | Location Identification | Equipment Category GE, CF, SE | *E. coli* CFU/mL | *Vibrio* CFU/mL | *Salmonella* CFU/mL | Coliforms CFU/mL |
|---|---|---|---|---|---|---|---|
| 1 | 17/10/2018 | Bar Cart Latch | GE | ND | ND | ND | TNTC |
| 2 | 17/10/2018 | DAM Cart Latch | GE | ND | ND | ND | ND |
| 3 | 17/10/2018 | Galley Doc Clip 1 | GE | ND | ND | ND | ND |
| 4 | 17/10/2018 | Galley Doc Clip 2 | GE | ND | ND | ND | ND |
| 5 | 17/10/2018 | Galley Latch for Cart 1 | GE | ND | ND | 8 | ND |
| 6 | 17/10/2018 | Galley Latch for Cart 2 | GE | ND | 6 | 48 | 94 |
| 7 | 17/10/2018 | Galley Latch for Cart 3 | GE | ND | ND | ND | TNTC |
| 8 | 17/10/2018 | Galley Latch for Cart 4 | GE | ND | ND | ND | ND |
| 9 | 17/10/2018 | Galley Latch for Cart 5 | GE | ND | ND | ND | ND |
| 10 | 17/10/2018 | Meal Cart 1 Handle | GE | ND | ND | ND | TNTC |
| 11 | 17/10/2018 | Meal Cart 1 Latch | GE | ND | ND | ND | TNTC |
| 12 | 17/10/2018 | Meal Cart 2 Handle | GE | ND | ND | ND | 3 |
| 13 | 17/10/2018 | Meal Cart 2 Latch | GE | ND | ND | ND | TNTC |
| 14 | 17/10/2018 | Meal Cart 3 Handle | GE | 41 | ND | 67 | 135 |
| 15 | 17/10/2018 | Meal Cart 3 Latch | GE | ND | ND | ND | TNTC |
| 16 | 17/10/2018 | Meal Cart 4 Handle | GE | ND | ND | ND | TNTC |
| 17 | 17/10/2018 | Meal Cart 4 Latch | GE | 6 | ND | ND | 145 |
| 18 | 17/10/2018 | Misc. Compartment Latch 1 | GE | ND | ND | ND | ND |
| 19 | 17/10/2018 | Misc. Compartment Latch 2 | GE | ND | ND | ND | 100 |
| 20 | 17/10/2018 | Oven 1 Knob | GE | ND | ND | ND | 169 |
| 21 | 17/10/2018 | Oven 1 Latch | GE | ND | ND | ND | ND |
| 22 | 17/10/2018 | Oven 2 Knob | GE | 62 | 47 | 293 | 117 |
| 23 | 17/10/2018 | Oven 2 Latch | GE | ND | ND | ND | ND |
| 24 | 17/10/2018 | Oven 3 Knob | GE | ND | ND | ND | ND |
| 25 | 17/10/2018 | Oven 3 Latch | GE | ND | 146 | ND | ND |
| 26 | 17/10/2018 | Oven 4 Knob | GE | 39 | 40 | TNTC | TNTC |
| 27 | 17/10/2018 | Oven 4 Latch | GE | ND | ND | ND | ND |
| 28 | 17/10/2018 | Water Boiler Faucet 1 | GE | 5 | 15 | 6 | ND |
| 29 | 17/10/2018 | Water Boiler Faucet 2 | GE | ND | ND | 11 | 12 |
| 30 | 17/10/2018 | Water Faucet Dispenser | GE | 43 | 11 | TNTC | TNTC |

Note:
CF, common facilities, i.e. lavatories
GE, Galley equipment
SE, Safety equipment
ND, Not detected
TNTC, Too numerous to count
BLR, Bengaluru
KUL, Kuala Lumpur

One sample was recorded at an unacceptable level of hygiene with a bacterial load of above 100 CFU/mL. Table 1 shows that these numbers excluded the 8 samples detected with the selected microorganism indicators. Table 5 shows cabin common facilities which included the lavatory 3L Flush, Lavatory 3RC Door Latch, Lavatory 3RC Flush, and Lavatory 3RR Door Latch. Three contaminated samples were also reported in the Safety Equipment category. These would include Assist Door Handle 4L, Crew Seatbelt D1R, and Handset at D1R. Only one galley equipment sample was contaminated which was identified to have belonged to the Oven Timer at Galley 21.

### *3.3 Enumeration and detection of Escherichia coli, Vibrio, Salmonella and coliforms on galley equipment, safety equipment samples taken from Narita to Kuala Lumpur flight sector*

The third microbiological lab work consisted of another 23 swab samples collected from an inbound flight originating from Narita (NRT), Tokyo International Airport Japan. Ten cabin common facilities, 6 galley equipment, and 7 safety equipment swab samples were enumerated for the detection of microorganisms (Table 6). It was reported that 20 samples did not show any bacterial contamination which was concluded as falling in the good level of hygiene. Only 1 sample was reported to show bacterial count that fell between 21 to 100 CFU/mL. Two samples were recorded at an unacceptable level of hygiene with a bacterial load of above 100 CFU/mL. It was identified that GE and CF recorded one and two samples, respectively. Table 6 shows that the common facility at Lavatory 3LL Flush and Lavatory 3CR Flush was reported to have a colony count of 39 CFU/mL and 123 CFU/mL, respectively. The galley equipment identified as Meal Cart Top6 was heavily contaminated with an average of 185 CFU/mL. It was reported that only 3 samples were contaminated with the microorganisms. Two samples generated from the CF and 1 sample resulted from the GE category. One plate count of *Salmonella* colony and 2 plate counts of 76 and 123 counts of coliforms were reported in the CF category. The average microbial load of the CF was 66.67 CFU/mL which fell within the acceptable level of hygiene. However, the microbial load for the GE was beyond the acceptable level of hygiene with *E. coli, Salmonella* and coliforms were reported at 151, 186 and 219 plate counts, respectively. The average microbial load of 185.33 CFU/mL. It was noted *Vibrio* was not detected in any of the SE category.

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### *3.4 Enumeration and detection of Escherichia coli, Vibrio, Salmonella and coliforms on galley equipment, safety equipment samples taken from Bengaluru to Kuala Lumpur flight sector*

The swab samples for this microbiological analysis were taken from galley equipment only. The microbiological results for this analysis were recorded in Table 7. All of the 30 swab samples taken for this microbiological analysis were that of the galley equipment. This study reported that only 10 samples were not detected with any of the microorganism indicators. In addition, four samples had a bacterial load that fell below 20 CFU/mL. Therefore, the total samples that fall within the good level of hygiene were reported at 14 samples altogether. Subsequently, 3 samples were reported to have a bacterial load that fell between 21 to 100 CFU/mL. These 3 samples which categorized as falling in the acceptable level of hygiene. However, the remaining 13 samples that were designated as fell within the not acceptable level of hygiene. It was worth noting that the overall environment hygiene of the galley equipment, safety equipment, and the cabin common facility, were denoted as good and acceptable levels. The results of the microbial analyses are appended in Table 4, 5, 6 and 7.

All of the 30 swab samples taken for this microbiological analysis were that of the galley equipment. It was reported that only 10 samples were not detected with any of the microorganism indicators. The remaining 11 samples had average 69.82 CFU/mL which was designated as fell within the acceptable level of hygiene. However, 9 samples had colony count characterized in the too numerous to count (TNTC) category, which fell into the unacceptable level of hygiene. The average plate counts for *E. coli* and *Vibrio* were reported at 32.67 and 44.17 CFU/mL. *Salmonella* and coliforms fell within the TNTC levels.

## 4. Discussion

The important finding that described the 99 swab samples collected for the microbial analyses was low prevalence of bacterial contamination. The colony counts for *E. coli* were reported at eight samples in which two colony counts of less than 20 CFU/mL, five had colony counts that fell between 20-100 CFU/mL and only one had more than 100 CFU/mL colony count. The colony counts for *Vibrio, Salmonella* and coliforms showed slightly higher numbers. These numbers, however, mostly fell within acceptable colony counts. It was reported that *Vibrio, Salmonella* and coliforms had seven, six and 11 colony counts that fell between 20 to 100 CFU/mL and less, respectively. Two, five and 18 fell beyond unacceptable plate counts of more than 100 CFU/mL. Only two and nine plate counts of *Salmonella* and coliforms fell in the too numerous to count category. It was worth noting that the overall environment hygiene of the GE, SE and the CF facilities, were denoted at good and acceptable levels. The results of the microbiological analyses were summarized in Table 1.

These environmental hygiene results suggested that personal hygiene which include washing of hands and sanitizing of galley equipment are imperative to prevent contamination and cross contamination alike. Flight attendants who regularly replenish the lavatories should be more concern towards the sterility over mere cleanliness of the lavatories. To sanitize the touching points and areas such as lavatories door knobs, latches and, buttons, facial mirrors and water faucets should become their second nature practices each time they utilize and replenish the lavatories.

*Escherichia coli* is a member of the bacterial family refers to as Enterobacteriaceae that normally live in the intestinal tracts of human and animals. Most *E. coli* are harmless and actually are important parts of a healthy human intestinal tract (Center of Disease Control, 2014). The prevalence of *E.coli* suggests fecal contamination potentially resorted from the hands of the flight attendants onto the galley and safety equipment or/and from the passengers hands who have access over and who simultaneously were frequent users of the cabin common facilities. Moreover, in due course of performing their duties throughout the flight sectors, the surfaces of galley equipment and cabin common facilities, i.e. lavatories service features such as door knobs, flush button switches, are unprotected and therefore are exposed to all sorts of bacterial contamination. Besides, given the favorable ambiance temperature in the cabin, which normally digitally selected at 22.5-23.5˚C (Operation Manual, 2020), is suitable for the growth and multiplication of bacteria. This temperature range is in accord to Membre *et al.* (2004) suggested that the conducive temperature for most bacteria fell within the range from 2 to 48˚C, depending on the bacterial species. In term of bacterial survival on surfaces, such bacteria as *E. coli* can survive in the surfaces of stainless steel at refrigerated and room temperatures condition (Wilks *et al*., 2004). Another study also suggested that *E. coli* has the capacity to survive on the surface of plastic material (Hedge, 2015). Lues and Van Tonder (2007) reported that various bacteria such as *E. coli* can survive on hands and surfaces for hours or even days after contact with the microorganisms. The prevalence of these bacterium indicators have made the studies to determine level of contaminations possible.

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Even though in most cases bacteria are harmless and thus unproblematic, they can also be pathogenic if found in the kitchen environment (Borusso and Quinlqn, 2017; Cogan *et al*., 2002). In which case when such pathogen as *Salmonella* are transferred from contaminated equipment and surfaces to food, it presents health risk and this has been reaffirmed through several studies where consumers may have used contaminated equipment or surfaces when preparing food (Redmond and Griffifth, 2003; Kennedy *et al*., 2011). As in the in-flight service environment, the flight attendants have limited possibilities in knowing when and how their galley equipment and galley worktop area are contaminated with pathogenic bacteria. From the perspective of food safety, kitchen hygiene is well guarded to ensure the number of pathogens are kept at safe levels (Bloomfield *et al*., 2017). However, kitchen environment also potentially contains large numbers of bacteria (Rusin *et al*., 1998; Moen, *et al*., 2016; Cardine *et al.,* 2017). This significant bacterial load as mentioned above concurs to the outcome of a study completed by Mutalib *et al*. (2015) where neglecting of the importance of food premise hygiene and good sanitation can increase the risk of foodborne illness. Similarly, study conducted by Nik Rosmawati *et al.* (2014) suggested that cleanliness of the primary school canteens and improper personal hygiene have resulted into unsatisfactory total plate count (TPC). Given the right ambiance temperature and time, *E. coli* can easily multiply to the extent that its prevalence is detrimental to health and safety.

Within the confinement of the airplane, the galley environment may contain a range of dirt or even different types of soil residues trapped from crewmembers' and passengers' clothes and footwear. Certain type of dirt residues may contain harmful pathogens which can potentially become a risk factor to foodborne illnesses. Personal hygiene and hygiene of personal effects such as clothing and footwear are not known and their cleanliness is also unknown to us because there have been no studies that relate the evaluation of such cleanliness in terms of bacterial load factors. While travelling, passengers and flight attendants quite often groomed themselves by touching the eyes, nose and face. They are also frequent users of the lavatories. The same occupants would touch the lavatories door knobs, water dispensers, flush switch buttons among other things. As part and partial of their in-flight duties, the flight attendants are responsible to ensure that the common cabin facilities such as the lavatories are well maintained. They may have done a fabulous job in ensuring the cleanliness of the lavatories. However, the physical appearance of the lavatories does not confirm the true hygiene of the area until environmental swab samplings are taken for microbial analysis.

Galley equipment reported to have been contaminated with 43 microorganisms. Nine of which were that of *Salmonella*. *E. coli, Vibrio* and coliforms were reported at seven, six and 21 samples, respectively. One sample of *Vibrio* and three samples of coliforms were also reported in the SE category. It was worth noting that no *E. coli* and *Salmonella* was detected on the SE category. This study also identified a total of 10 samples have been contaminated with *E. coli, Vibrio, Salmonella* and coliforms at 1, 2, 2 and 5 samples, respectively. Looking at a clean, dry and neat appearance of the lavatories can be pleasing to the eyes. Yet the degree of contamination as proved by the prevalence of microorganism indicators is the hazard that every occupants have to endure throughout the flight sector. Concurs to the research by Margas *et al*. (2014) *Salmonella* is generally regarded as tolerant to desiccation where they reported that *Salmonella* can survive in dry condition on stainless steel for a period more than 4 weeks. Therefore, environment that seem neat, tidy, and dry do not necessarily signify a bacterial free environment.

Correspondingly, prevalence of coliforms in general indicates the presence of fecal contamination. The primary sources of coliforms are from animal intestinal tract of warm-blooded animals other than from soil and vegetation (Treyens, 2009). From this analyses, the GE indicated prominent level of coliform contamination followed by the CF. This may have contributed by frequent handling and usage of the GE. The nature of their working processes are such that these equipment are regularly retrieved and utilized as when in-inflight service are required. The in-flight service expectation is that the flight attendants are to accommodate and attend attentively to dine-on-demand (DOD) gracefully with high standard of finesse. Given this scenario, cross contamination is highly likely because flight attendants are continuously on their feet and are constantly in touch with the passengers and spend considerable amount of time with them (Maslach and Jackson, 1981).

Therefore, personal hygiene which include washing of hands and sanitizing of galley equipment is essential to prevent contamination and cross contamination. In addition, flight attendants who regularly replenish the lavatories should not only be more concerned towards the cleanliness but also more apprehensible about the sterility of lavatories. To sanitize the sensitive points and areas such as lavatory door knobs, latches and, buttons, facial mirrors and water faucets should become their second nature practices each time and every time when their assistance are required.

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## Conclusion

The environmental hygiene of all three focal areas were categorically evaluated based on each bacterium indicator. The findings revealed that the environmental hygiene of the GE, SE and CF showed a low prevalence of bacterial contamination where 24 (4.4%), 4 (4.04%) and 6 (6.06%) samples were reported, respectively. Bacterial colony were not detected in 65 samples. The report concluded that 69 (67.7%) samples fell within the good level of hygiene where 12 (12.12%) samples were reported as having acceptable level of hygiene. However, 18 (18.2%) samples indicated to have unacceptable level of hygiene. Having analyzed all of the swab samples, it is quite imperative that the flight attendants to be able to work and create a safe and sterile working environment. This is very important because as frontliners, the flight attendants, are routinely using and handling these equipment and facilities. To highlight and create awareness of the importance in practicing good housekeeping as much as maintaining good personal hygiene behavior among the flight attendants is therefore important. Failing to do so may pose a high risk of cross contamination that potentially lead to food poisoning. To the very least, there are much more other considerations to be accounted for about the potential risk of foodborne illnesses. The environmental equipment and facilities in the airplane are therefore no exception.

## Conflict of interest

There was no conflict of interest when this study was conducted and the outcome of this research is a valuable contribution to the body of knowledge which focuses on a particular attention to in-flight food handling and in-flight food safety in Malaysian aviation scenario.

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