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Rapid Food Hygiene Inspection Tool (RFHiT) to assess hygiene conformance index (CI) of street food vendors

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1 **Rapid Food Hygiene Inspection Tool (RFHiT) to assess hygiene conformance index (CI) of**
2 **street food vendors**

3
4 **Abstract**

5
6 Street-vended food is a popular choice among consumers as they are cheap, convenient and easily
7 accessible, especially in Asia. Studies have assessed street food vendors' food safety and
8 microbiological quality of street-vended foods and overall findings revealed gaps and inconsistencies
9 in hygiene practices. High numbers of street food vendors vs low numbers of environmental health
10 officers and limited time remains a challenge in most developing countries in assessing the hygiene
11 compliance of food services. Most inspections rely on paper-based assessments of the cleanliness and
12 hygiene practices of staff. This study developed a Rapid Food Hygiene Inspection Tool (RFHiT) to
13 assess and calculate the hygiene conformance index (CI) of 95 street food vendors. RFHiT allows
14 rapid assessment as it takes less than 20 minutes to assess each street food vendor. 51.30% of the
15 street food vendors were rated as moderately clean whilst 14.25% were rated as poor and 0.95% as
16 very poor. 20% of the vendors achieved a good rating with six street-food vendors rated as excellent.
17 The proposed tool further demonstrated practical implications of using the rapid inspection tool to
18 assess actual hygienic practices of street food vendors, thus reducing the Hawthorne effect among
19 food handlers.

20
21 **Keywords:** conformance index; food handlers; food safety; hygiene; premises; preparation

22
23 **Highlights**

- 24 • A new tool for rapid hygiene assessment of street food vendors is proposed.
25 • Allow rapid and discrete assessment of hygiene compliance among street food vendors.
26 • Calculation of conformance index (CI) and CI_{REL} allow critical comparison and prioritisation of
27 resources.

28
29 **Introduction**

30 WHO (2015) estimated that a total of 600 million of foodborne diseases worldwide resulted in more
31 than 400,000 deaths in 2010. The main causes of foodborne disease were attributed to diarrhoeal
32 disease agents especially norovirus and *Campylobacter* spp. Diarrhoeal disease agents that caused
33 the highest number of deaths were non-typhoidal *Salmonella enterica*. Other major causes of
34 foodborne deaths were *Salmonella typhi*, *Taenia solium*, hepatitis A virus and aflatoxin (WHO, 2015).
35 Foodborne diseases arises from the contamination of food by microbiological contamination, naturally
36 produced toxins or chemicals (van Seventer, & Hamer, 2017). Foodborne diseases in South East Asia
37 is largely caused by unhygienic practices. Street food vendors and schools were found to be common
38 settings for foodborne outbreaks to take place (Dewanti-Hariyadi, & Gitapratwi, 2014). In Malaysia,
39 the five most significant pathogens isolated from stool samples of diarrhoeal patients were
40 nontyphoid *Salmonella*, enteropathogenic *Escherichia coli*, *Shigella*, *Campylobacter* and *Aeromonas*
41 (Dewanti-Hariyadi & Gitapratwi, 2014). Studies reported that up to 55% (n=187) of the investigated
42 *Salmonella* isolates from vegetables and processing environment (Abatcha, Effarizah, & Rusul, 2018),
43 99% (n=114) of *Salmonella* from poultry and processing environment (Chuah, Syuhada, Suhaimi,
44 Hanim, & Rusul, 2018) and 54% of *Campylobacter* isolates (n=59) in cattle and beef meat
45 (Premarathne et al., 2017) were multi-drug resistant. Recent studies by Woh et al. (2017) revealed
46 that non-typhoidal *Salmonella* exist among migrant food handlers. Some of the *Salmonella* isolates
47 were found to be multi-drug resistant against ampicillin, chloramphenicol, trimethoprim-
48 sulfamethoxazole, sulphonamides, streptomycin and tetracycline. This poses food safety and health
49 risks to consumers through food contamination.

50

51 In Malaysia, the main contributing factor to foodborne diseases were identified as unsanitary food
52 handling practices which accounted for more than 50% of the reported food poisoning incidents
53 (Soon, Singh, & Baines, 2011). Street food vending in Malaysia generates a multi-million US dollar
54 trade providing direct employment to vendors and food handlers (Alimi, 2016; Shafiee, Ab Karim,
55 Mohamed Razali, & Ungku Zainal Abidin, 2017). Street foods are described as ready-to-eat food and
56 beverages that are prepared and sold by vendors in public places. The stalls are often located
57 outdoors, or under a roof which is easily accessible from the street (Winarno & Allain, 1991) and are
58 often vended from mobile or stationary stalls. Street foods are attractive to consumers due to its

59 location, accessibility and affordable prices. The vendors are often found in major street corners,
60 construction sites, bus or train terminals, fresh food or wet markets, night markets, nearby schools or
61 other major business centres. However, the environment in which the food is prepared and sold are
62 exposed to potential contamination (Alimi, 2016). Study by Leong et al. (2010), revealed that
63 although tourists were very satisfied with food prices, flavours, variety and availability of food whilst
64 travelling in Malaysia, there were concerns about the sanitation and hygiene level of food stalls in
65 Malaysia. Unhygienic and/or contaminated street food could be potential source of foodborne
66 diseases. Travellers often develop acute diarrhoea during their stays in tropical and subtropical
67 regions (Sanders, Riddle, Taylor, & DuPont, 2019). For example, von Sonnerburg et al. (2000)
68 reported that two of three tourists developed traveller's diarrhoea whilst vacationing in high risk
69 destinations. Enterotoxigenic *E. coli*, *Campylobacter jejuni* and other bacterial enteropathogens were
70 the most common cause of acute diarrhoea (Sanders et al., 2019).

71

72 A number of food safety studies among street food vendors had been conducted globally. In Kolkata,
73 India, 71% of street food vendors operate in contaminated areas, 57% had no dustbin facilities and
74 67% had no access to nearby toilet facilities (Ghatak & Chatterjee, in press). In Vietnam, food
75 vendors were found to have poor food safety knowledge and attitude levels and operate under
76 largely unhygienic environments (Samapundo, Cam Thanh, Xhaferi, & Devlieghere, 2016). Similarly,
77 street food vendors in Haiti were found to operate under unhygienic conditions although they
78 exhibited average food safety and attitude levels (Samapundo, Climat, Xhaferi, & Devlieghere, 2015).
79 Trafialek et al. (2018) conducted a comparative study of food hygiene practices in Asia and EU and
80 found many non-compliances in hygienic practices, although the surveyed EU country showed higher
81 conformity in food hygiene practices than in Asian countries. Most studies assessed street food
82 vendors and food handlers' self-reported food hygiene practices. Few studies utilised an inspection
83 tool to assess the level of hygiene compliance among food services. The vast number of street food
84 vendors that need to be inspected by environmental health officers or food safety inspectors remain a
85 challenge in developing countries. Trafialek, Drosinos and Kolanowski (2017) developed a fast
86 observation questionnaire to assess street food vendors' hygienic practices while Santana, Almeida,
87 Ferreira and Almeida (2009) calculated the hygiene compliance of catering facilities using a checklist.

88 In addition to assessing individual street food vendors, there is currently no tool that assess and
89 compare the hygiene conformance of street food vendors. This study aims to develop a Rapid Food
90 Hygiene Inspection Tool (RFHiT) to assess and calculate the hygiene conformance index of street
91 food vendors.

92

93 **Methodology**

94 **Rapid Food Hygiene Inspection Tool (RFHiT)**

95 The items in RFHiT is designed to assess the compliance of hygienic requirements of street food
96 vendors (Table 1). It is divided into five parts: Part 1: Premises and food preparation area (17
97 questions); Part 2: Preparation (5 questions); Part 3: Storage (6 questions); Part 4: Serving (4
98 questions) and Part 5: Hygiene practices (12 questions). The questions were developed primarily
99 based on Food Hygiene Regulations (2009). The Regulations aim to control the hygiene and safety of
100 food sold in the country to protect public health and consist of seven main sections including: Part I –
101 Preliminary (e.g. definition of terminologies e.g. potable water, sanitary); Part II – Registration of
102 food premises; Part III – Conduct and maintenance of food premises (e.g. location, design, water
103 supply, cleanliness, pest control, disposal); Part IV – Food handler (e.g. personal hygiene); Part V –
104 Special requirements in handling specifif food (e.g. meat, fish, ice); Part VI – Carriage of food (e.g.
105 cleanliness, separation of food from non-food item) and Part VII – Miscellaneous (e.g. penalty) (Food
106 Act 1983 [Act 281], 2012). The questions were largely derived from Food Hygiene Regulations Part
107 III to Part VI, Santana et al. (2009), Trafialek et al. (2017) and Trafialek et al. (2018). Food hygiene
108 items that were deemed more likely to result in cross contamination of food and increased public
109 health risks were awarded two points. Criteria for the definition of each food hygiene scoring was
110 based on review of literature (Santana et al. 2009; Trafialek et al. 2018) and Food Hygiene
111 Regulations (2009).

112

113 Insert Table 1 here

114

115 The food hygiene items from Table 1 were adapted into Bristol Online Survey (BOS) system which
116 allows observation to be carried out using a smartphone. Factor analysis using a varimax rotation was

117 conducted to establish construct validity (DeVon et al., 2007; Gu et al., 2018). Construct validity is
118 the extent to which the instrument (in this case – RFHiT) measures the construct it is intended to
119 measure (DeVon et al., 2007). Construct validity was selected as it evaluates the appropriateness of
120 an instrument for a specific purpose (i.e. hygiene assessment) and to determine the level of
121 confidence one can place on the assessment scores using RFHiT (Streiner et al., 2015). The Kaiser-
122 Meyer-Olkin (KMO) value of more than 0.60 and factor loading of 0.40 and above indicates adequate
123 relationship of each item in the underlying factor (Hair et al., 2009). RFHiT was pilot-tested at three
124 street food vendors and open street restaurant at both peak (12 – 2pm) and non-peak hours (3 –
125 5pm). After pilot-testing RFHiT, it was noted that street food vendors have different ideas of pest-
126 deterring techniques, reliance on ice-boxes and some stalls provided limited eating area. Hence
127 additional questions i.e. 1.6 (Did you observe other forms of pest deterring devices?), 3.3 (Ice box is
128 used) and 4.4 (Customer serving / eating area (tables, chairs, floor) are kept clean) were added. Six
129 research assistants well versed in food safety management systems were trained. All users learnt to
130 apply the observation method and to use RFHiT. The validation method was based on the World
131 Health Organization hand hygiene observation method (Sax et al., 2009; Stewardson et al., 2013).
132 Before conducting the hygiene observation session, the users were validated by the principal
133 investigator. All six users engaged in the hygiene observation session at two street food vendors and
134 completed the hygiene assessment. Results were then reviewed, compared and discordant
135 notifications were discussed (Sax et al., 2009). The intra-class coefficient was calculated to determine
136 the inter-rater reliability (ICC). ICC estimate was calculated using SPSS version 25.0 based on 2-way
137 mixed effects model and consistency. Values less than 0.5 indicate poor reliability, 0.5 – 0.75 indicate
138 moderate reliability, 0.75 and 0.9 indicate good reliability and values greater than 0.90 indicate
139 excellent reliability (Koo, & Li, 2016).

140

141 Street food vendors were selected at random in eight cities and towns throughout Peninsular Malaysia
142 including Kota Bharu in Kelantan, Johor Bahru in Johor, Kota Melaka in Melaka, Butterworth and
143 Georgetown, Penang (31), Ipoh and Tronoh in Perak (16) and Kajang, Selangor (15) and were
144 evaluated using the Rapid Food Hygiene Inspection Tool. The street food vendors included in this
145 study are street restaurants (open restaurants located in permanent premises and situated next to

146 traffic and are easily accessible by public), street food booths or kiosks (food stalls with minimal
147 facilities and could be re-located easily), mobile food cart or food truck (food stalls operated from a
148 motorised vehicle / bicycle / pushcart), night market stall (similar to mobile food carts or trucks but
149 only operate at night in specific locations) and wet market stall (food booths located within a market
150 place with shared facilities such as public toilets and waste collection).

151

152 **Compliance with hygienic requirements**

153 The street-food vendors' food hygiene compliance were calculated using the formula below. The
154 formula was modified from Santana et al. (2009) .

155

$$156 \quad P = \left(\frac{TS}{\Sigma_1 - \Sigma_2} \right) \times K$$

157

158 Where P = Part 1 to 5 (Part 1: Premises and preparation area, P2: Preparation, P3: Storing, P4:
159 Serving, P5: Hygiene);

160 TS = Total score;

161 Σ_1 = Total possible points;

162 Σ_2 = Total non-applicable points;

163 K = constant, where K values for P1 = 38.41; P2 = 11.69; P3 = 16.70; P4 = 6.64 and P5 = 26.72

164 ($\Sigma K = 100$) (The logic for calculation K values can be provided upon request)

165

166 **Formula 1. Calculation of food hygiene compliance**

167

168 The total score is the score obtained for a specific area of assessment e.g. Premises and Preparation
169 area. In Σ_1 , the total possible points are – Part 1: Premises and preparation area = 23; P2:

170 Preparation = 7; P3: Storing = 10; P4: Serving = 4 and P5: Hygiene = 16. The non-applicable points

171 (Σ_2) are equal to the points awarded for 'yes' and are deducted from the total possible points to

172 remove potential confounding factors that may arise from calculating non-existing variables. For

173 example, sections related to food preparation will be noted as not applicable if a street food vendor

174 does not have a food preparation area and only sells wrapped, ready-to-eat foods directly. This is to
175 avoid distortion of the final hygiene score. The mean score of the five parts was calculated as:
176 $(P1+P2+P3+P4+P5/10)$ and the street food vendors were classified according to a scale: 0 – 1.9
177 (very poor: urgent improvement necessary); 2.0 – 4.9 (poor: major improvement necessary); 5.0 –
178 6.9 (moderate; some improvement required); 7.0 – 8.9 (good) and 9.0 – 10.0 (excellent).

179

180 **Calculation of conformance index formula**

181 A conformance index formula was adapted from Dzwolak (2016) to compare the total conformance
182 index % of the street food vendors. This formula is useful to compare conformance % according to
183 location, type of facilities, number of employees or food hygiene requirements.

184

$$185 \quad CI = \left(\frac{\sum_{i=1}^n ES \times N_{SFV_i}}{AMES_{N_{SFV}}} \right) \times 100$$

186

187 Where, CI = Conformance index (%)

188 Es: Evaluation score;

189 N_{SFV} : number of street food vendors;

190 AMES: Adjusted maximal evaluation score (calculated as number of food stalls x maximal evaluation
191 score [10]. Note that the number of food stalls is dynamic and is adjusted according to the number of
192 assessments. Meanwhile the maximul evaluation score is fixed at 10).

193

194 **Formula 2. Calculation of conformance index (CI)**

195

196 The CI is then converted into relative state which range from 0 – 1 using the following formula:

197

$$198 \quad CI_{REL} = \frac{CI_{cur} - CI_{min}}{CI_{max} - CI_{min}}$$

199

200 Where CI_{REL} = relative state of CI (between 0 – 1);

201 CI_{cur} = current CI under evaluation;

202 CI_{min} = minimum value of CI

203 CI_{max} = maximum value of CI

204 Formula 3. Calculation of relative conformance index (CI_{REL})

205

206 **Results**

207 Exploratory factor analysis was carried out to test the construct validity. The Kaiser-Meyer-Olkin
208 (KMO) measure of sampling value for was 0.66. This fulfills Hair et al. (2010) who stated that the
209 criterion of validity should be > 0.60 , indicating the principal component analysis (PCA) was
210 appropriate. PCA was performed using varimax rotation. All factor loadings were > 0.40 and
211 explained 45.46% of the total variance. A high degree of reliability was found between the hygiene
212 observations among the users. The average ICC measure was 0.89, $F(1, 5) = 9.90, p < 0.05$.

213

214 Ninety five street food vendors were evaluated using the Rapid Food Hygiene Inspection Tool
215 (RFHiT). Street food vendors located in major cities or towns in six states in Peninsular Malaysia i.e.
216 Johor ($n = 19$), Kelantan ($n=11$), Melaka ($n=3$), Penang (31), Perak (16) and Selangor (15) were
217 randomly selected and observed. Each street food vendor was evaluated for an average of 17
218 minutes. Table 2 shows the characteristics of the street-vended food stalls. Street restaurants, night
219 market stalls and street food booths represent the top three types of food stalls observed in the
220 study. Most of the food stalls were operated by two food handlers and sold freshly prepared meals,
221 ready to eat meals and beverages. More than half (57%) of the street food vendors were located
222 near to traffic (57%) or heavy traffic (20%), open drains (33.25%) and rubbish collection point
223 (16.15%).

224

225 Insert Table 2 here

226

227 The individual hygiene scores for all street food vendors are shown in Supplementary data. 30.5% of
228 the food stalls were either located under a tree, bridge, under public stairways or walkways. 20.9% of

229 food stalls used Ultra Violet (UV) fly traps to catch insects. Street restaurants (11) were the most
230 frequent users as their outlets were permanent and could easily install a UV trap in their restaurant.
231 Food stalls that do not use UV fly traps used other forms of pest deterring devices ranging from
232 plastic bags filled with grease to trap insects, lit candles, portable fan, fly swatter, glue trap and
233 polyethylene film to cover food products. 31.4% of the premises have access to toilet facilities. Of
234 this, 66.67% were observed to be visually clean, not smelly and contain running water. 60.61% of
235 the facilities provided adequate soap or foam for handwashing. 45.6% of the food stalls do not have
236 access to running water.

237

238 14.74% of the food stalls were observed to use equipment such as knives and chopping boards for
239 both raw and cooked food. During food preparation, raw food came into direct contact with cooked
240 food in 3.80% of the food stalls. 57.95% of the food stalls immediately prepared and served or sold
241 food according to order. This helps to ensure foods are served warm or cold depending on type of
242 food or beverages sold. Storage capacity is limited among street food vendors. This is evident by the
243 lack of cold storage facilities where only 20.90% had a chiller and/or freezer to store their food
244 products. Forty eight stalls used iceboxes for cold storage. Although foods were prepared and served
245 on visually clean utensils or packaging materials, 52.25% of the food stalls did not store the cutleries,
246 plates or packaging materials appropriately and are prone to contamination.

247

248 Four food handlers were observed to be eating or chewing gum whilst preparing food while nine of
249 the street food vendors were smoking. One food handler was observed to have visible cuts on his/her
250 hands. 72.2% of the street food vendors had short, clean and unpainted nails and 49.40% did not
251 wear any jewellery including watches. Less than half of the food handlers (42.75%) were found to
252 wear caps or hair covers (including turbans / headscarves). Of those wearing hair covers, 82.22%
253 covered their hair fully. Street food vendors were also found to keep their clothes clean and
254 presentable (77.90%) and 57.95% wore clean aprons whilst handling food. An estimated 26% of the
255 street food vendors touched their face, nose, ears or hair whilst handling food and 20% were found
256 to use their bare hands to handle unwrapped ready-to-eat food. Only 33.25% were observed to wash
257 their hands after handling items such as raw food, dustbin and cash.

258

259 Insert Figure 1 here

260

261 51.30% of the street food vendors were rated as moderately clean whilst 14.25% were rated as poor
262 and 0.95% as very poor. 20% of the vendors achieved a good rating with six street-food vendors
263 rated as excellent (Figure 1).

264

265 **Conformance index**

266 Results of calculation of the Conformance Index % are shown in Table 3. Street food vendors in
267 Selangor demonstrated the highest compliance for the evaluation criterion under analysis. Wet
268 market stalls and street restaurants represented the facilities with higher rate of conformance
269 compared to other types of street food vending facilities. Calculations of the relative values of CI_{REL}
270 are presented in Figure 2. The radar charts allow one to visualise the size of the areas of compliance.
271 There were variations between different regions e.g. ranging from CI_{rel} 0 in Perak to CI_{REL} 1 in
272 Selangor.

273

274 Insert Table 3 here

275

276 Insert Figure 2 here

277

278 **Discussion**

279

280

281 The rapid assessment conducted in this study demonstrated that street food vendors' overall hygiene
282 compliance were moderate and required improvement. This study reiterates previous studies where
283 street food vendors' hygienic practices were not satisfactory (Muyanja, Nayiga, & Nasinyama, 2011;
284 Samapundo et al., 2015; Trafialek et al., 2018). A number of street food vendors were often located
285 near traffic and other areas e.g. open drains, rubbish collection point, building or construction sites
286 and / or even near toilet facilities. This poses a problem as food products are constantly exposed to

287 potential contamination from the open environment, e.g. dust, smoke from motorised vehicles, pests
288 and physical contamination especially if the street food vendor is located under walkways / stairways
289 / bridge. A number of open street restaurants in Malaysia are within vicinity of open drains and pests
290 including stray dogs and cats could easily access the premises. Street food vendors may prefer to
291 select location with easy access to high number of customers, despite the fact that the location may
292 not be as hygienic or easy to maintain good hygienic practices. Interviews conducted by Pang and
293 Toh (2008) revealed that hawkers preferred to work on the roadside than being relocated to a
294 designated site due to better business and less competitors on the roadside.

295

296 The lack of running water facility and reliance on bottled water may discourage food handlers from
297 washing their hands and utensils. Food stalls that used buckets of water may re-use the water to
298 wash their hands, utensils and raw materials. This poses the risk of contamination via the re-used
299 water. Contaminated water is a vehicle for foodborne pathogens such as *E. coli*, *Salmonella* spp. and
300 *Campylobacter* spp (Rane, 2011). The lack of adequate supply of potable water remains one of the
301 most critical problem among street food vendors (Dawson, & Canet, 1991; Rane, 2011). In Mankee et
302 al. (2003), the authors found street food products that came from vendors with no water supply at
303 their food stalls had significantly higher number of unfit samples compared to vendors with water
304 supply. The lack of toilet facilities is another cause for concern. This may also impact on food
305 handlers' handwashing practices due to the lack of facilities and time (e.g. street food vendors may
306 need to walk or search for the nearest public toilet).

307

308 Street food vendors are categorised as micro or small food businesses and operate with minimal
309 capital and resources including storage capacity. Although some of the food vendors utilised ice
310 boxes, this warrants further investigation – particularly in terms of segregating raw and ready to eat
311 food in different, labelled ice boxes. Malaysia is a tropical country with average temperature ranging
312 from 27°C to 33°C (Climate-data, n.d.). The hot and humid weather is an attractive factor for street
313 food vendors especially those selling cold desserts and beverages but the warm weather is conducive
314 to bacterial foodborne pathogens such as *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*
315 and *Vibrio* spp. (Bryan, 2004). This was evident in previous studies where multi-drug resistant

316 *Klebsiella pneumonia* were isolated in 32% of street foods (n=78) (Haryani et al., 2007) and 35% of
317 fresh vegetables / salad (n=43) purchased from wet market stalls in Malaysia were positive for
318 *Salmonella* (Salleh et al., 2003). Al Mamun, Rahman and Turin (2013) reported unsatisfactory
319 coliform levels in 44% of food samples (n=110) collected from school-based street food vendors
320 while foodborne pathogens including *Escherichia coli*, *Staphylococcus aureus*, *Listeria*
321 *monocytogenes*, *Shigella* and *Enterobacteriaceae* were found in street vended ready-to-eat meats
322 (Shiningeni, Chimwamurombe, Shilangale, & Misihairabgwi, 2019). Poor personal hygiene especially
323 the lack of handwashing after handling dirty items were observed in this study. Previous studies
324 reported 46% (Liu, Zhang, & Zhang, 2014) and 76% (Ghatak, & Chatterjee, 2018) of street food
325 vendors did not wash their hands after handling contaminated materials. Woh et al. (2017) isolated
326 non-typhoidal *Salmonella* and multi-drug resistant *Salmonella* from migrant food handlers in Malaysia
327 (Woh et al., 2017). Unsatisfactory personal hygiene may cross contaminate food products with
328 foodborne pathogens leading to potential foodborne illnesses.

329

330 Selangor was ranked highest in hygiene compliance compared to other states. A number of factors
331 could affect the ranking e.g. number of food hygiene inspections carried out by the local authorities,
332 food handlers' knowledge and attitude, food safety training and education, and consumer's demands.
333 This study was conducted in July and August of 2018 and coincided with the nation's food safety
334 incident where food handlers in a street restaurant in Selangor were filmed washing dishes in a
335 puddle of dirty water by the roadside (NST, 2018). The film was shared on social media over
336 YouTube, blogs, Twitter, Whatsapp and online news. It went viral and garnered more than 300,000
337 views and 750 comments. Comments i.e. 'boycott the restaurant', 'ban', 'hygiene', 'health authorities'
338 and 'inspection' were commonly expressed by the online community (YouTube, 2018). Ultimately, the
339 restaurant was shut down by local health authorities for unhygienic practices (The Star Online, 2018).
340 It is possible that street food vendors were aware of the food safety news and consumers demand
341 stricter food safety inspections from the local authorities. The unfortunate incident may have
342 increased food handlers' awareness and attitudes towards food hygiene and safety. The variations
343 between different regions could potentially be due to ineffectiveness of food safety strategies of local
344 control authorities (Pang, & Toh, 2008). Although the street food vendors found the food safety

345 guidelines clear and understandable, the guidelines were deemed impractical and this potentially
346 discourages the hawkers adherence to food safety guidelines (Pang & Toh, 2008). Pang and Toh
347 (2008) also reported that socio-demographic factors i.e. ethnicity, religion and education of food
348 handlers may affect the implementation of food safety strategies.

349

350 The type of street food vending facilities influenced the level of conformity with hygienic
351 requirements. Wet market stalls were found to have the highest level of compliance followed by
352 street restaurants. Having access to appropriate hygiene facilities increase the level of hygiene
353 compliance by wet market stalls and street restaurants. Traditional wet markets in Malaysia are
354 typically open food market where floors are routinely washed. Wet markets sell live animals, fresh
355 fish, fresh produce and food products. A number of disease outbreaks are commonly transmitted
356 through food and live animals in markets. The World Health Organization (2006) introduced the
357 Healthy Food Markets to improve the safety of foods sold in urban markets. One of the key
358 recommendations were the improvements in physical infrastructure e.g. provision of sufficient toilet
359 and handwashing facilities, adequate potable water supply, proper drainage and regular waste
360 disposal from closed containers and zoning of areas to prevent cross contamination. To date, wet
361 market stalls in Malaysia are undergoing urban renewal process and relocated to hygienic building
362 areas (Md Sharif, Md Nor, Mohd Zaharia, & Muhammad, 2015). Street restaurants are located in
363 permanent buildings with access to chilled and/or frozen storage, water supply, toilet facilities and
364 kitchen sinks. Trafialek et al. (2018) reported street restaurants tend to have the highest conformity
365 due to the appropriate social facilities and restaurant management.

366

367 RFHiT allows rapid assessment as it takes less than 20 minutes to assess each street food vendor. In
368 standard food safety inspections, it was found that hawkers "only wear hats to show the authorities
369 when they come to check" (Pang & Toh, 2008). Using RFHiT on a smartphone enables discrete
370 observation of street food vendors and allow inspectors to assess the actual hygienic practices of food
371 handlers, effectively reducing the Hawthorne effect (change in behaviour) among food handlers.
372 Direct observation may result in workers changing their behaviour when they know that they were
373 being observed and can result in falsely elevated compliance rates (Haas & Larson, 2007). Training of

374 food inspectors and/or assessors in observation methods and use of RFHiT must be carried out to
375 ensure validity and reliability. As a start, inspectors could carry out the assessment with a trained
376 observer at a number of sites and the results are then compared and any discordant notifications
377 could be discussed. The ICC value for test-retest reliability or inter-rater reliability should be more
378 than 0.75 to achieve good consistency. Calculation of compliance scores and CI_{REL} allows one to rate
379 the food hygiene compliance and visualise the size of the areas of compliance according to location,
380 type of facilities or number of employees (not calculated here). There is also potential to compare the
381 historical data and evaluate if hygiene improvements were made over the years. Further
382 enhancement to RFHiT could be made to enable food inspectors to show street food vendors which
383 area of assessments could be further improved. Resources such as food handlers' training and food
384 safety awareness programme, provision of designated and hygiene facilities could potentially be
385 provided to areas that require urgent improvement to ensure food hygiene practices and reduction in
386 foodborne illnesses.

387

388 Although RFHiT allows rapid assessment of the hygienic practices of street food vendors, this could
389 be potentially be a limitation as the rapid assessment only observe the hygiene practices of the street
390 food vendors for a small window of time. Although RFHiT is easy to use, food inspectors must be
391 trained to ensure rigorous and consistent assessment and interpretation of hygiene compliance rate.
392 There is a total of 43 questions in the tool to cover the essential inspections especially cleanliness and
393 hygiene practices of the food handlers. Some food safety inspectors may find using the tool as an
394 additional burden on top of the existing, food safety and hygiene inspections. However, this tool os
395 not to replace current, existing legal compliance checks but is a rapid, starting point for further
396 inspections. The findings in this study should be not be generalised as the hygiene conformance
397 indexes are calculated for the specific street food vendors.

398

399 **Conclusion**

400 This study proposed a new rapid food hygiene assessment tool to determine the level of hygiene
401 conformance among street food vendors. Assessment of street food vendors revealed food hygiene
402 gaps and provides the data necessary for the improvement of regulations and policies. Street food

403 vendors are often located near traffic and other less hygienic areas including open drains, rubbish
404 collection point, building or construction sites and / or even near toilet facilities. This poses a problem
405 as food products are constantly exposed to potential contamination from the open environment. The
406 findings clearly show that provision of appropriate hygiene facilities and infrastructure can help to
407 improve food hygiene practices. The proposed tool further demonstrated practical implications of
408 using the rapid assessment tool to assess actual hygienic practices of food handlers, effectively
409 reducing the Hawthorne effect among food handlers.

410

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414

415 **References**

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587

588 Table 1. Street-food vendors’ food hygiene items in Rapid Food Hygiene Inspection Tool

| No. | Items in RFHiT | Yes | No | Not applicable (N/A)* |
|----------|--|-----|----|--------------------------|
| (Scores) | | | | |
| 1 | Premises | | | |
| 1.1 | Shop / stall is protected from sun, wind and dust | 1 | 0 | 1 |
| 1.2 | Shop / stall area is located in clean area (e.g. not situated near rubbish area, heavy traffic, large opened drains) | 1 | 0 | 1 |
| 1.3 | Shop / stall is NOT located under a tree, bridge, stairs, walkway or other unhygienic areas | 1 | 0 | 1 |
| 1.4 | Shop / stall area is maintained in a clean condition | 1 | 0 | 1 |
| 1.5 | Is there a working fly trap visible in the work place? | 1 | 0 | 1 |
| 1.6 | Did you observe other forms of pest deterring devices? | 1 | 0 | 1 |

| No. | Items in RFHiT | Yes | No | Not applicable (N/A)* |
|------------|--|------------|-----------|------------------------------|
| 1.7 | Is the premise generally free from pests e.g. insects (apart from the insects trapped in the fly trap) animals, rodents, pets? | 2 | 0 | 2 |
| 1.8 | Are there toilet facilities for staff? | 2 | 0 | 2 |
| 1.9 | Toilet facilities are clean, not smelly and with running water | 2 | 0 | 2 |
| 1.10 | Adequate soap or foam provided | 2 | 0 | 2 |
| | Food preparation area | | | |
| 1.11 | Food preparation / cooking area is constructed of materials that are easy to clean and smooth | 1 | 0 | 1 |
| 1.12 | Food preparation area is kept in clean and good order | 2 | 0 | 2 |
| 1.13 | There is supply of clean, running water | 2 | 0 | 2 |
| 1.14 | Handwashing facilities are available nearby | 1 | 0 | 1 |
| 1.15 | Food stalls do not re-use water in buckets | 1 | 0 | 1 |
| 1.16 | Utensils and dishes are washed in kitchen sink | 1 | 0 | 1 |
| 1.17 | Utensils and dishes are NOT stored and accumulated in basin | 1 | 0 | 1 |
| 2.0 | Preparation | | | |
| 2.1 | Cooking appliances / utensils are maintained in good condition and clean | 1 | 0 | 1 |
| 2.2 | Separate equipment such as knives and cutting boards are used for handling raw food | 2 | 0 | 2 |
| 2.3 | Food is prepared and served immediately | 2 | 0 | 2 |
| 2.4 | During food preparation, raw / fresh food is not in direct contact with cooked food | 1 | 0 | 1 |

| No. | Items in RFHiT | Yes | No | Not applicable (N/A)* |
|--------------------|---|------------|-----------|------------------------------|
| 2.5 | Separate utensils (e.g. chopping boards, tongs, chopsticks) are used to serve cooked foods | 1 | 0 | 1 |
| 3.0 Storage | | | | |
| 3.1 | Raw or fresh foods are stored separately from ready to eat food | 2 | 0 | 2 |
| 3.2 | A fridge or freezer is used to store food | 2 | 0 | 2 |
| 3.3 | Ice box is used | 1 | 0 | 1 |
| 3.4 | Food is stored / displayed in a covered container | 1 | 0 | 1 |
| 3.5 | Food is kept hot if the food is to be served hot (N/A if food is prepared and served immediately) | 2 | 0 | 2 |
| 3.6 | Food is kept cooled if the food is to be served chilled (N/A if food is prepared and served immediately) | 2 | 0 | 2 |
| 4.0 Serving | | | | |
| 4.1 | Food is served with clean and safe packaging materials (e.g. no newspaper in direct contact with food) | 1 | 0 | 1 |
| 4.2 | Food is served with clean utensils / plates | 1 | 0 | 1 |
| 4.3 | Utensils / plates / packaging materials are stored and protected against contamination | 1 | 0 | 1 |
| 4.4 | Customer serving / eating area (tables, chairs, floor) are kept clean (N/A if no eating area is provided) | 1 | 0 | 1 |
| 5.0 Hygiene | | | | |
| 5.1 | Cook / staff does not eat or chew gum whilst handling food | 1 | 0 | 1 |

| No. | Items in RFHiT | Yes | No | Not applicable (N/A)* |
|-------------|---|-----|----|-----------------------|
| 5.2 | Cook / staff does not smoke whilst handling food | 1 | 0 | 1 |
| 5.3 | Cook / staff has no visible cuts or visible skin diseases symptoms on hands uncovered by gloves | 2 | 0 | 2 |
| 5.4 | Cook / staff has short, clean (and not painted) nails | 2 | 0 | 2 |
| 5.5 | Cook / staff wears caps / hair covers (including headscarf / turban) | 1 | 0 | 1 |
| 5.6 | Hats or hair covers effectively prevent hair from falling into food | 1 | 0 | 1 |
| 5.7 | Cook / staff does not wear jewellerys, watches, pins or other accessories | 1 | 0 | 1 |
| 5.8 | Cook / staff does not touch face, nose, ears or hair whilst handling food | 1 | 0 | 1 |
| 5.9 | Cook / staff does not use bare hands to handle unwrapped ready to eat food | 2 | 0 | 2 |
| 5.10 | Cook / staff's clothes are clean and presentable | 1 | 0 | 1 |
| 5.11 | Cook /staff uses a clean apron when handling food | 1 | 0 | 1 |
| 5.12 | Cook / staff wash or clean hands after handling unclean items e.g. raw food, money, dustbin etc | 2 | 0 | 2 |
| Total score | | 60 | | |

589 *Note that the non-applicable points are deducted from the total possible points to remove potential confounding
590 factors and avoid distortion in the final hygiene score.
591

592 Table 2. Characteristics of street-vended food stalls (n=95)

| Items | Frequency (%) |
|---|---------------|
| Type of facilities | |
| Street restaurant (exposed to opened environment) | 27 (25.7) |

| Items | Frequency (%) |
|---|----------------------|
| Street food booth / kiosk | 24 (22.8) |
| Mobile food cart / food truck | 8 (7.6) |
| Night market stall | 26 (24.7) |
| Wet market stall | 3 (2.9) |
| Others | 7 (6.7) |
| | |
| Number of employees | |
| One | 16 (15.2) |
| Two | 41 (39.0) |
| Three | 15 (14.3) |
| Four or more | 23 (21.9) |
| | |
| *Type of food sold | |
| Freshly prepared meals (e.g. noodles, chapatti, burgers) | 42 |
| Ready meals (e.g. economy rice, nasi lemak, prepared noodles) | 32 |
| Savoury food (e.g. steamed buns, glutinous rice) | 25 |
| Desserts (cakes, confectionaries, ice kacang [Malaysian shaved ice dessert], cendol [sweet, iced dessert]) | 24 |
| Beverages | 31 |
| Fruits and vegetables | 14 |
| Others | 7 |
| | |
| *Location or point of sale is near: | |
| Heavy traffic (next to main roads) | 21 |
| Traffic (next to roads with occasional traffic) | 60 |
| Opened drains | 35 |
| Rubbish collection point / skip | 17 |

| Items | Frequency (%) |
|------------------------------------|----------------------|
| Toilet facilities | 7 |
| Building site or construction area | 8 |
| Others | 14 |

593 *Street food vendors sold more than one type of food and were exposed to one or more areas prone to
594 contamination

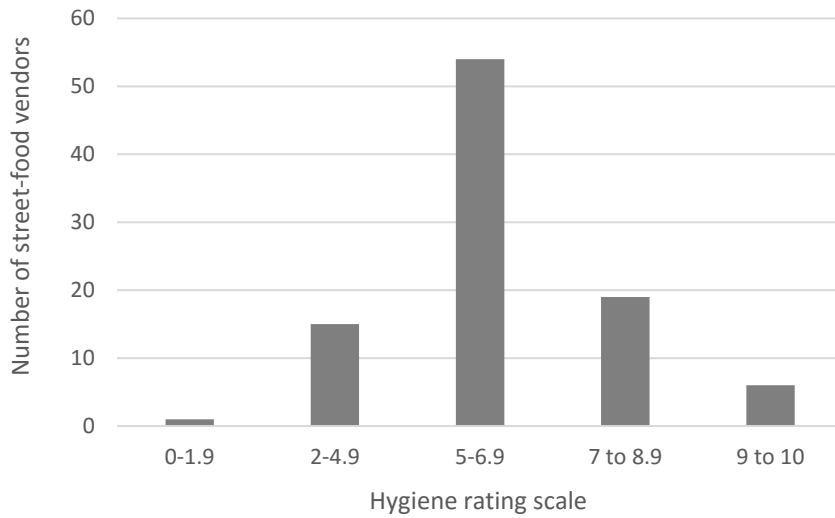
595

596 Table 3. Conformance index according to states and type of facilities

| States | Conformance index % |
|-------------------------------|----------------------------|
| Johor | 64.56 |
| Kelantan | 64.35 |
| Melaka | 65.77 |
| Penang | 59.85 |
| Perak | 50.44 |
| Selangor | 76.94 |
| Facilities | |
| Street restaurant | 70.60 |
| Street food booth / kiosk | 52.61 |
| Mobile food cart / food truck | 58.54 |
| Night market stall | 58.99 |
| Wet market stall | 83.27 |
| Others | 65.83 |

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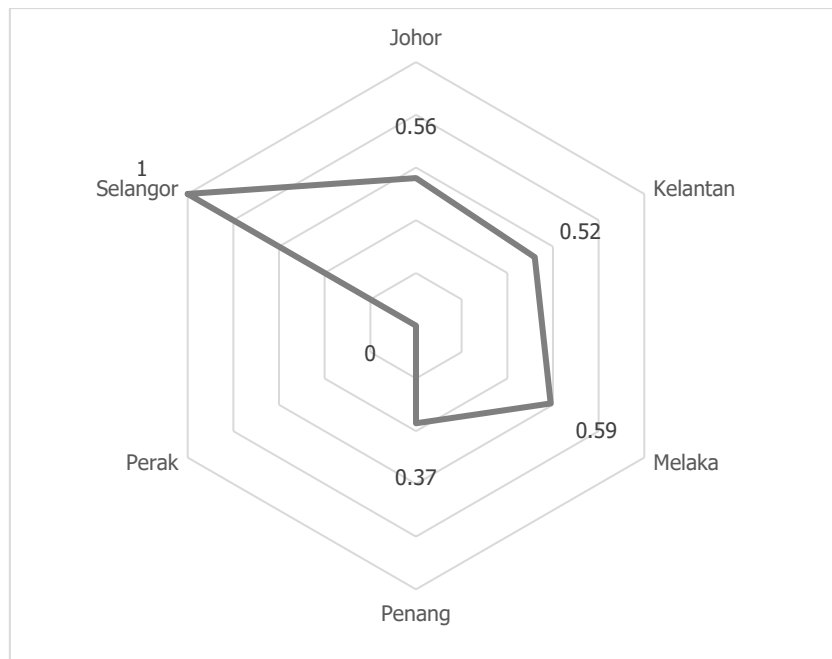
Figure 1. Hygiene ratings of observed street food vendors (n=95). Note: 0 – 1.9 (very poor [urgent improvement necessary]); 2.0 – 4.9 (poor [major improvement necessary]); 5.0 – 6.9 (moderate [some improvement required]); 7.0 – 8.9 (good) and 9.0 – 10.0 (excellent).

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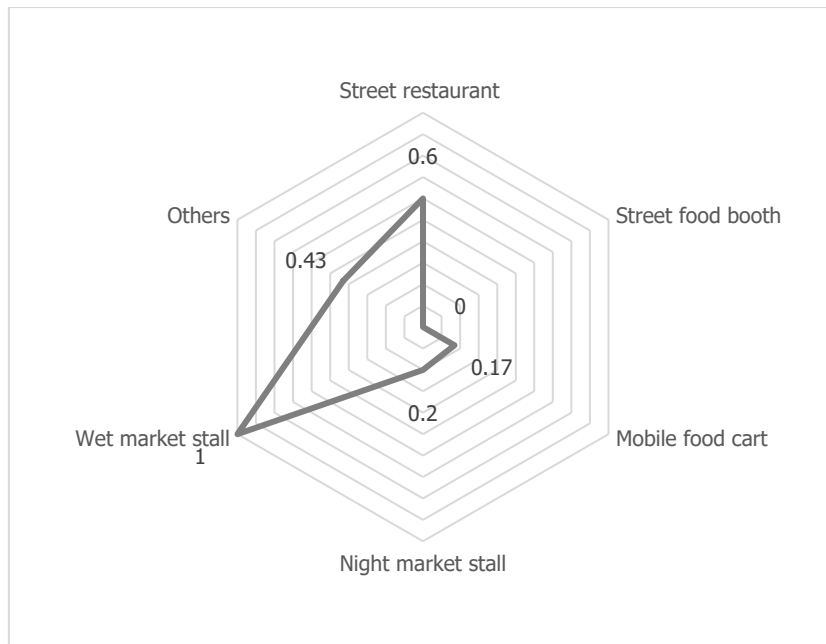


(a)

605

606

607



(b)

608
609
610

611 Figure 2. CI_{REL} of street food vendors according to (a) states and (b) type of street food vending
612 facilities (n=95)

613

614 **Supplementary data**

615 Table 1. Total score for P1 – P5 (Part 1: Premise, P2: Preparation, P3: Storing, P4: Serving, P5:

616 Hygiene) and hygiene rating of observed street food vendors (n=95)

| Part | Part 1 | Part 2 | Part 3 | Part 4 | Part 5 | Total score / 10 |
|------|--------|--------|--------|--------|--------|------------------|
| J1 | 20.95 | 8.35 | 14.61 | 5.01 | 15.03 | 6.40 |
| J2 | 15.03 | 11.69 | 8.35 | 5.01 | 18.37 | 5.85 |
| J3 | 6.06 | 11.69 | 8.35 | 4.45 | 18.37 | 4.89 |
| J4 | 11.30 | 11.69 | 8.35 | 6.68 | 26.72 | 6.47 |
| J5 | 6.98 | 5.01 | 5.01 | 6.68 | 15.03 | 3.87 |
| J6 | 14.15 | 6.68 | 3.71 | 3.34 | 20.04 | 4.79 |
| J7 | 21.34 | 11.69 | 10.44 | 6.68 | 21.71 | 7.19 |
| J8 | 9.04 | 8.35 | 4.18 | 4.45 | 25.05 | 5.11 |
| J9 | 25.05 | 11.69 | 11.13 | 6.68 | 21.71 | 7.63 |
| J10 | 15.82 | 11.69 | 5.57 | 6.68 | 26.72 | 6.65 |
| J11 | 20.33 | 3.90 | 16.70 | 6.68 | 26.72 | 7.43 |
| J12 | 33.40 | 11.69 | 11.13 | 6.68 | 25.05 | 8.80 |

| Part | Part 1 | Part 2 | Part 3 | Part 4 | Part 5 | Total score / 10 |
|-------------|---------------|---------------|---------------|---------------|---------------|-------------------------|
| J13 | 35.07 | 11.69 | 13.92 | 6.68 | 26.72 | 9.41 |
| J14 | 20.33 | 11.69 | 11.13 | 6.68 | 26.72 | 7.66 |
| J15 | 18.08 | 11.69 | 5.57 | 6.68 | 23.38 | 6.54 |
| J16 | 11.30 | 11.69 | 8.35 | 6.68 | 23.38 | 6.14 |
| J17 | 14.94 | 11.69 | 8.35 | 6.68 | 21.71 | 6.34 |
| J18 | 13.56 | 11.69 | 5.57 | 6.68 | 20.04 | 5.75 |
| J19 | 13.56 | 8.35 | 5.57 | 6.68 | 23.38 | 5.75 |
| | | | | | Total score | 122.67 |
| K1 | 26.72 | 10.02 | 15.03 | 1.67 | 10.02 | 6.35 |
| K2 | 34.37 | 11.69 | 13.36 | 6.68 | 26.72 | 9.28 |
| K3 | 23.64 | 8.35 | 11.13 | 5.01 | 15.03 | 6.32 |
| K4 | 18.19 | 11.69 | 14.61 | 5.01 | 16.70 | 6.62 |
| K5 | 20.22 | 8.35 | 13.92 | 5.01 | 15.03 | 6.25 |
| K6 | 12.80 | 11.69 | 0.00 | 3.34 | 16.70 | 4.45 |
| K7 | 8.09 | 11.69 | 5.57 | 6.68 | 20.04 | 5.21 |
| K8 | 35.07 | 11.69 | 11.13 | 6.68 | 23.38 | 8.80 |
| K9 | 6.78 | 11.69 | 5.57 | 2.23 | 16.70 | 4.30 |
| K10 | 14.40 | 10.02 | 8.35 | 4.45 | 23.38 | 6.06 |
| K11 | 20.22 | 11.69 | 11.13 | 6.68 | 21.71 | 7.14 |
| | | | | | Total score | 70.78 |
| M1 | 20.33 | 11.69 | 11.13 | 6.68 | 21.71 | 7.15 |
| M2 | 14.15 | 11.69 | 4.18 | 4.45 | 20.04 | 5.45 |
| M3 | 16.17 | 11.69 | 10.02 | 6.68 | 26.72 | 7.13 |
| | | | | | Total score | 19.73 |
| P1 | 7.68 | 8.35 | 6.26 | 3.34 | 19.09 | 4.47 |
| P2 | 27.44 | 6.68 | 8.35 | 5.01 | 21.38 | 6.89 |
| P3 | 26.72 | 6.68 | 0.00 | 5.01 | 19.09 | 5.75 |
| P4 | 29.26 | 11.69 | 0.00 | 5.01 | 16.70 | 6.27 |
| P5 | 30.06 | 11.69 | 8.35 | 5.01 | 20.99 | 7.61 |
| P6 | 27.11 | 8.35 | 10.02 | 5.01 | 18.37 | 6.89 |
| P7 | 20.12 | 6.68 | 8.35 | 5.01 | 20.04 | 6.02 |
| P8 | 16.80 | 6.68 | 8.35 | 3.34 | 18.37 | 5.35 |
| P9 | 19.21 | 10.02 | 8.35 | 4.45 | 17.18 | 5.92 |

| Part | Part 1 | Part 2 | Part 3 | Part 4 | Part 5 | Total score / 10 |
|-------------|---------------|---------------|---------------|---------------|---------------|-------------------------|
| P10 | 22.24 | 11.69 | 4.18 | 5.01 | 13.36 | 5.65 |
| P11 | 24.26 | 11.69 | 4.18 | 5.01 | 17.81 | 6.29 |
| P12 | 21.95 | 2.34 | 8.35 | 5.01 | 21.71 | 5.94 |
| P13 | 18.37 | 3.90 | 0.00 | 4.45 | 19.09 | 4.58 |
| P14 | 29.87 | 3.90 | 0.00 | 4.45 | 19.59 | 5.78 |
| P15 | 24.26 | 3.90 | 4.18 | 5.01 | 17.18 | 5.45 |
| P16 | 21.34 | 8.35 | 3.34 | 4.45 | 16.70 | 5.42 |
| P17 | 16.46 | 8.35 | 5.01 | 4.45 | 21.71 | 5.60 |
| P18 | 22.59 | 8.35 | 10.02 | 4.45 | 20.04 | 6.55 |
| P19 | 22.59 | 0.00 | 8.35 | 4.45 | 21.71 | 5.71 |
| P20 | 21.34 | 3.90 | 0.00 | 4.45 | 20.04 | 4.97 |
| P21 | 20.33 | 8.35 | 5.57 | 4.45 | 16.70 | 5.54 |
| P22 | 20.33 | 3.90 | 12.53 | 4.45 | 21.71 | 6.29 |
| P23 | 20.33 | 11.69 | 11.93 | 4.45 | 20.04 | 6.84 |
| P24 | 22.59 | 6.68 | 11.13 | 5.01 | 20.04 | 6.55 |
| P25 | 19.21 | 6.68 | 5.57 | 5.01 | 15.03 | 5.15 |
| P26 | 26.28 | 11.69 | 5.57 | 5.01 | 18.37 | 6.69 |
| P27 | 21.34 | 8.77 | 0.00 | 4.45 | 16.70 | 5.13 |
| P28 | 16.46 | 0.00 | 3.34 | 4.45 | 16.70 | 4.10 |
| P29 | 30.32 | 8.35 | 5.57 | 4.45 | 19.09 | 6.78 |
| P30 | 26.28 | 11.69 | 13.92 | 6.68 | 18.37 | 7.69 |
| P31 | 30.06 | 11.69 | 10.44 | 5.01 | 19.59 | 7.68 |
| | | | | | Total score | 185.55 |
| PK1 | 30.32 | 11.69 | 16.70 | 6.68 | 16.70 | 8.21 |
| PK2 | 8.09 | 5.01 | 8.35 | 1.67 | 10.02 | 3.31 |
| PK3 | 4.80 | 11.69 | 8.35 | 4.45 | 10.02 | 3.93 |
| PK4 | 14.40 | 11.69 | 10.44 | 4.45 | 15.03 | 5.60 |
| PK5 | 22.24 | 11.69 | 8.35 | 6.68 | 11.69 | 6.06 |
| PK6 | 22.24 | 10.02 | 13.92 | 5.01 | 16.70 | 6.79 |
| PK7 | 16.17 | 8.35 | 8.35 | 3.34 | 13.36 | 4.96 |
| PK8 | 2.74 | 3.90 | 0.00 | 4.45 | 8.35 | 1.94 |
| PK9 | 0.00 | 8.35 | 5.57 | 4.45 | 10.02 | 2.84 |
| PK10 | 16.46 | 11.69 | 8.35 | 5.01 | 16.70 | 5.82 |

| Part | Part 1 | Part 2 | Part 3 | Part 4 | Part 5 | Total score / 10 |
|-------------|---------------|---------------|---------------|---------------|---------------|-------------------------|
| PK11 | 13.97 | 5.01 | 11.13 | 2.23 | 15.03 | 4.74 |
| PK12 | 15.03 | 6.68 | 16.70 | 3.34 | 8.35 | 5.01 |
| PK13 | 31.73 | 11.69 | 16.70 | 5.01 | 15.03 | 8.02 |
| PK14 | 11.82 | 0.00 | 4.18 | 4.45 | 13.36 | 3.38 |
| PK15 | 6.98 | 0.00 | 16.70 | 4.45 | 5.01 | 3.31 |
| PK16 | 16.17 | 11.69 | 16.70 | 5.01 | 18.37 | 6.79 |
| | | | | | Total score | 80.71 |
| S1 | 12.00 | 11.69 | 4.18 | 4.45 | 16.70 | 4.90 |
| S2 | 26.72 | 11.69 | 11.13 | 6.68 | 26.72 | 8.29 |
| S3 | 12.13 | 11.69 | 16.70 | 6.68 | 21.71 | 6.89 |
| S4 | 31.73 | 11.69 | 16.70 | 5.01 | 16.70 | 8.18 |
| S5 | 36.74 | 11.69 | 14.61 | 6.68 | 23.38 | 9.31 |
| S6 | 11.69 | 11.69 | 16.70 | 6.68 | 15.03 | 6.18 |
| S7 | 31.73 | 11.69 | 16.70 | 6.68 | 25.05 | 9.19 |
| S8 | 35.07 | 11.69 | 16.70 | 6.68 | 26.72 | 9.69 |
| S9 | 22.59 | 11.69 | 16.70 | 6.68 | 21.71 | 7.94 |
| S10 | 20.33 | 2.34 | 16.70 | 6.68 | 23.38 | 6.94 |
| S11 | 15.71 | 3.90 | 16.70 | 6.68 | 15.03 | 5.80 |
| S12 | 36.66 | 11.69 | 16.70 | 6.68 | 21.71 | 9.34 |
| S13 | 31.73 | 11.69 | 13.92 | 6.68 | 21.71 | 8.57 |
| S14 | 26.28 | 11.69 | 15.03 | 6.68 | 26.72 | 8.64 |
| S15 | 12.13 | 0.00 | 16.70 | 5.01 | 21.71 | 5.55 |
| | | | | | Total score | 115.41 |

617 Note: J: Johor; K: Kelantan; M: Melaka; P: Penang; Pk: Perak; S: Selangor

618

619