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Association between fish consumed and mercury levels in fishermen hair

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ABSTRACT This study was initialised to investigate the relationship between the amount of fish intake and mercury levels for the critical group of fishermen living in Doha Fishing Village, Kuwait. Mercury levels data taken from the hair of the fishermen was analysed and interpreted. In terms of the data, there are a total of 135 observations, consisting of a critical group of fishermen and a control group of construction workers. The participants from these two groups were assumed to be independent and randomly picked. Both methylmercury and total mercury data have a highly skewed and non-normal distribution. Normality test of log-transformed data for methylmercury and total mercury returned significant results, indicating the log-transformed data also pointed towards a non-normal distribution. Preliminary analysis including exploratory analysis and correlation tests was done to observe each independent variable separately and inspect their relationship with mercury levels (outcome variable). As it appeared only weight and height data followed a Normal distributions, and that outliers were detected, a test of statistical difference between group medians was preferable to that of group means. Generalized linear model (GLM) of Gamma family with an inverse link was chosen over Multiple Linear Regression model, because descriptive statistical graphs have shown there was no linear relationship between fish meals per week and mercury concentration levels. Moreover, the outcome variables were non-negative and continuous hence choosing GLM from a Gamma distribution seems like an appropriate choice. The best models was then picked using AIC backwards elimination. Residual diagsnotics were performed on the chosen models to check if they complied with the residual assumptions. The final results showed that there was a relationship between the amount of fish consumed and mercury levels with weak evidence and only applied to those that consumed exactly 7 fish meals per week.

Key Words *Mercury levels, Total mercury, Fishermen, Hair samples, Weekly fish consumption, Kruskal Wallist's correlation test, Spearman's correlation test, Generalized linear models, DHARMa residual plots*

Based on the following article:
Factors influencing the total mercury and methyl mercury in the hair of the fishermen of Kuwait by *N.B. Al-Majed* and *M.R. Preston* Environmental Pollution. 109: 239-250.

I. INTRODUCTION

MERCURY(Hg) for a long time has been infamous for its highly toxic compounds and a dangerous health hazard to humans, with main source of exposure being fish consumption. Moreover, it has been proven in several past studies that mercury concentration levels showed a positive correlation with fish consumed (*N. B. Al-Majed et al., 2000 [6]*).

Mercury comes in different forms, but the most common form that is most likely associated with mercury poisoning is MeHg short for methylmercury (organic mercury in water-soluble form). In fact, nearly all of the mercury in fish muscle is methylmercury (*M. M. Storelli et al., 2003 [5]*). According to *A. Bou-Olaya et al., 1994 [3]*, the mean of MeHg represents approximately 96% the mean of total mercury (TotHg). Another study by *F. W. Lipfert et al., 1995 [4]* showed that the values for TotHg in fish vary between 0.3μg/g fresh weight set by the US Environmental Production Agency (EPA) (with not more than 66% in the form of organic Hg), which means methylmercury level in fish was still above average and concerning.

A study by *ROMPE, 1988 [8]* investigated whether different species of fish has different mercury levels in the Arabian (Persian) Gulf region, where Kuwait fishing village is located. As an example, total Hg values in fish of the region were estimated to range between 0.007μg/g (wet wt.) for Mediterranean amberjack (Seriola dumerlii) and 0.540μg/g (wet wt.) in Karanteen sea beam (Crenidens crenidens). *N. B. Al-Majed et al., 1998 [1]* also reported total Hg and MeHg levels in 105 samples of 23 different species. The levels of total Hg varied between 0.123μg/g (dry wt.) in river shad (Hilso ilisha) of 450g weight and 35cm length to 4.500μg/g in Indian flat head (Platycephalus indicus) of 1200g weight and 47cm length. The corresponding MeHg values were 0.015μg/g and 3.862μg/g, respectively.

The relationship between fish consumption and mercury levels is believed to be dependent on other factors such as edible parts of fish, sizes of fish, etc. *H. Augier et al., 1993 [2]* have outlined different concentrations of total Hg in different organs (liver, lung, kidney, muscle, heart and brain) of same species of fish and reported that the highest levels of Hg were found in the brain and other fatty tissues. Furthermore, *P.Houserova et al., 2006 [7]* agreed that the total mercury concentration levels in fish is not related only to the mercury content in the sediments, but also to the diet composition of the fish, and to the other chemical and biological characteristics of the aquatic ecosystem.

The present study aims to investigate the relationship between the amount of fish intake and mercury levels for the critical group, fishermen living in Doha Fishing Village, Kuwait, using the data derived from the article of interest.

II. SAMPLING METHODS

A. Sample collection and preparation

100 human hair samples were collected from fishermen (age range 25 – 60 years old) living in Doha Fishing village, Kuwait. Thirty-five additional samples were taken from a control group working in a local construction company (age range 26 – 35). All participants were men. The hair samples were taken from several sites of the scalp of each individual using clean stainless-steel scissors. Each sample was cut into short segments and washed successively with acetone and water. After being separated by centrifugation and dried in a laminar flow hood, hair samples were placed in a polyethylene plastic sampling bag. These sampling bags were then labelled separately and stored in a deep freezer until the time of analysis.

B. Questionnaire details

A questionnaire was completed for each participant to provide more information regarding their dietary habits and other related factors. Questions related to dietary habits are number of fish meals per week (`fishmlwk`) and parts of fish eaten(`fishpart`). Other factors included are age (`age`), height (`height`), weight (`weight`) of the participants and their residence time in Kuwait (`restime`).

C. Analysis and Quality Control of MeHg

About 0.2g of dry sample was analysed based on the *UNEP, 1987 [9]* standards. The final determination was carried out on an HP Gas Chromatograph Model 5890 Series II, equipped with glass column of 1.6 m length and 2mm internal diameter, packed with 5% DEGS±PS (diethylene glycol succinate modified with phosphoric acid) on 100±120 mesh (Supelco) and an electron capture detector, using nitrogen as the carrier gas. The accuracy of MeHg analysis was inspected by running two Sample Reference Materials (SRMs) with each set of eight samples. The recovery varied in the range 92.4±105.8%. Two blank samples were run with each set and the results show no detectable levels of MeHg. Finally, 18% of the samples were analysed in triplicate to check the reproducibility of the analysis.

The coefficient of variation was 0.40±4.01%. (*N. B. Al-Majed et al., 2003 [6]*

D. Analysis and Quality Control of TotHg

About 0.2g of the dry sample was dissolved with 4 ml of nitric acid and 2ml of sulfuric acid, for 2 hours at room temperature and then 3 hours at 90°C. The final determination was carried out using a PSA Hydride Vapor Generator connected to an Atomic Fluorescence Detector Model 10.023. A 20% Tin(II) Chloride solution was used as a reducing agent, 1% nitric acid solution was used as a blank, and argon was used as the carrier gas. The accuracy of the analysis was examined by running four samples of SRM with each set of 25 samples. Recovery rate was between 94.6% and 98.9%. Six blank samples were also run with each set where the results show undetectable levels of total mercury in all of the analysed blank samples. In order to check the reproducibility of the analysis, 23% of the samples were analysed in triplicate and one SRM out of four samples was also treated in the same manner. The coefficient of variation was 0.08±2.95%. (*N. B. Al-Majed et al., 2003 [6]*

III. Statistical Methodology

The aim of this report is to examine a potential relationship between the amount of fish intake for fishermen only and levels of mercury concentration. For this reason, the control group of construction workers can be excluded from the statistical analysis of the data. This brings the sample size from $N = 135$ observations down to $N = 100$ observations.

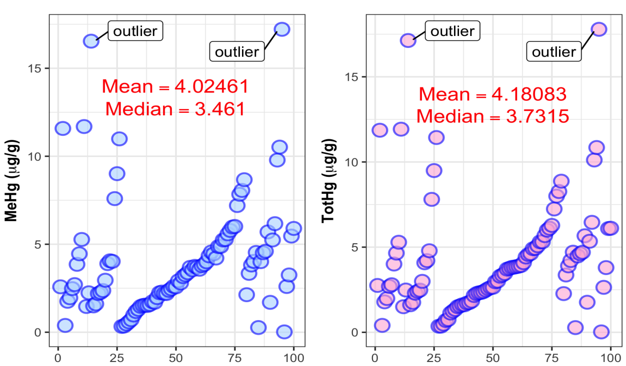

FIGURE 1. Scatter graph plotting methylmercury concentration (left) and total mercury concentration (right) in fishermen with outliers detected

The fishermen data set of interest has a total of 6 independent variables and two outcome variables, `MeHg` and `TotHg`. Statistical tests were done to evaluate the significance of correlation between the independent variables and the outcome variables. In summary, **Kruskal-Wallis test of medians** and **Spearman's rank correlation test** were used (Table 2) for categorical variables and continuous variables, respectively. The Kruskal-Wallis test is a rank-based test that can be applied to data with more than two groups. Spearman's rank correlation test is a non-parametric test used to measure the degree of association between continuous independent variables and `MeHg` variable.

A. Preliminary Analysis

Descriptive statistics of the independent and dependent variables, and correlation test results are displayed in this section.

A.1. Methylmercury

From looking at Figure 2, it is clear that the `MeHg` variable does not follow a Normal distribution. A normality test

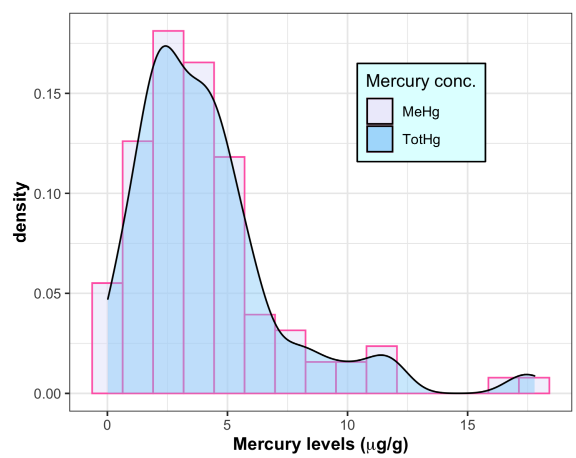

FIGURE 2. Histogram displaying the distribution of the methylmercury (MeHg), overlayed by TotHg density curve

using the **Shapiro-Wilk's method** was also conducted on the log-transformed data to check if the logarithm of `MeHg` follows a Normal distribution. The result of the normality test returned a p-value much smaller than the significance level $\alpha = 0.05$. Therefore, `MeHg` also does not follow a Log-Normal distribution.

A.2. Total mercury

`TotHg` has a similar right-skewed distribution to that of `MeHg`. The log-transformed data of `TotHg` also returned a significant p-value obtained from the normality test at 5% level. Figure 1 shows a couple of outliers detected in `MeHg` and `TotHg` variables and because both distribution are skewed, Spearman's rank correlation test was picked as an alternative to Pearson's correlation test. The p-value of Spearman's correlation is <0.001 with ρ = 0.99748, indicating a very strong positive relationship between `MeHg` and `TotHg`. Since these variables are highly correlated, the correlation tests with independent variables will only involve `MeHg` as the results for `MeHg` will be similar to that for `TotHg`.

A.3. Fish meals per week

`fishmlwk` is the main independent variable of interest as it is related to the research question, describing the amount of fish each fisherman consumed per week. It has 5 levels of categories, as shown in the table below.

TABLE 1. **Distribution of levels of `fishmlw`**

levels	3	4	7	14	21
Total observations	2	12	70	5	11

I decided to make some changes to the `fishmlwk` variable by combine some of the levels together. More specifically, levels 3 and 4 were combined, and levels 14 and 21 were also combined, resulting in a total of three groups, i.e. **group** <**7** (lowest fish consumption), **group 7** (medium fish consumption) and **group** >**7** (highest fish consumption).

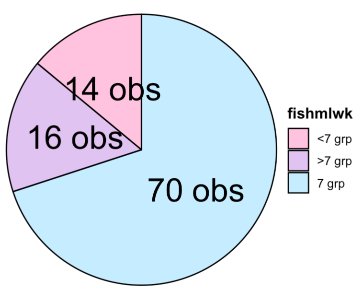

FIGURE 3. **Pie chart showing the distribution of `fishmlwk` variable after groups combining**

The reason for doing this is because there are very few observations in some of the original levels. In doing so, the sample size will be increased leading to more accurate results. A test of difference between group medians through Kruskal-Wallis method was picked over than a test of difference between group means because medians are more robust to outliers, and is an appropriate test to use as the groups of `fishmlwk` variables have similar distribution shapes (see Figure 4). The test returned non-significant result for `fishmlwk` group differences in `MeHg` levels with χ^2 = 3.9171 (> critical χ^2 = 5.991) and p-value > 0.05.

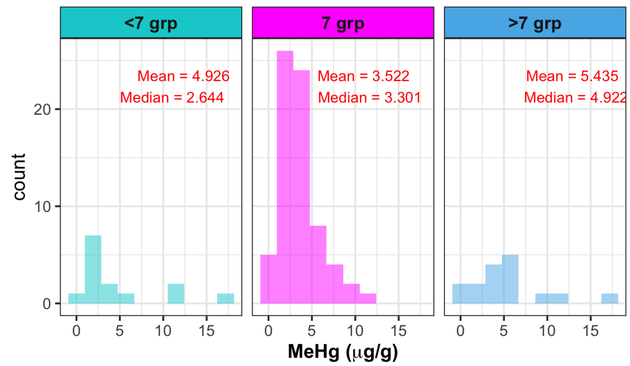

FIGURE 4. **Histogram plotting the distribution of `fishmlwk` variable groups against MeHg**

A.4. Parts of fish eaten

There are three groups representing the fish parts consumption preferences amongst the fishermen. *Group 1*

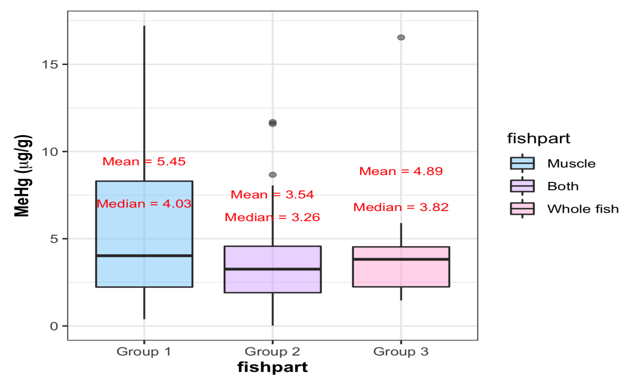

FIGURE 5. **Boxplot plotting 3 groups of `fishpart` variable against methylmercury concentration in fishermen variable**

describes those that consumes only the fish muscles, *Group 2* is those consumes the whole fish and *Group 3* is those with mixed consumption of fish muscles and whole fish. The medians are similar between the three groups (as seen in the Figure 5) though group 1 has a much wider range of `MeHg` concentration levels than the other two groups. Kruskal-Wallis test shows that there are no statistically differences between `fishpart` groups in `MeHg` levels.

A.5. Height and Weight

Looking at Figure 6, it appears that `height` and `weight` follow a Normal distribution. Spearman's ρ is reported as .200 and .401 for `height` and `weight`, respectively. This implies that there are some weak correlation between `height` and `MeHg` levels and moderate correlation between `weight` and `MeHg` levels. `weight` can also be seen increasing as `MeHg`

TABLE 2. Results of difference between `MeHg` in categorical variable groups test and correlation between `MeHg` and continuous variables test

Variable	Type	Distribution	Kruskal-Wallis test for group differences in MeHg	Spearman's correlation test w.r.t MeHg
`MeHg`	continuous	non-normal	—	—
`TotHg`	continuous	non-normal	—	ρ = 0.9975, p-value $<$ 2.2$\times 10^{16}$ ***
`fishmlwk`	categorical, 3 levels	non-normal	χ^2 = 3.9171, p-value = 0.1411	—
`fishpart`	categorical, 3 levels	non-normal	χ^2 = 2.3351, p-value = 0.3111	—
`age`	continuous	non-normal	—	ρ = 0.0537, p-value = 0.5956
`restime`	continuous	non-normal	—	ρ = 0.0390, p-value = 0.6999
`weight`	continuous	normal	—	ρ = 0.400985, p-value = 3.56$\times 10^{05}$ ***
`height`	continuous	normal	—	ρ = 0.200247 , p-value = 0.04576 .

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increases in Figure 7, indicating a positive linear relationship between the two variables.

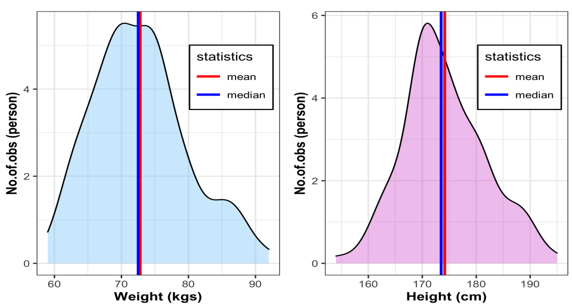

FIGURE 6. Density plots of `Weight` and `Height` variables

A.6. Age

Figure 7 shows the `MeHg` levels and `weight` controlled by `age`. The extreme outliers (`MeHg` $>$ 15 μg/g) seem to belong to fishermen of age ranged between 30 and 40 years. Since `age` is shown to be dispersed randomly with `MeHg` and Spearman's ρ is reported to be very small, there is no correlation between `age` and `MeHg`.

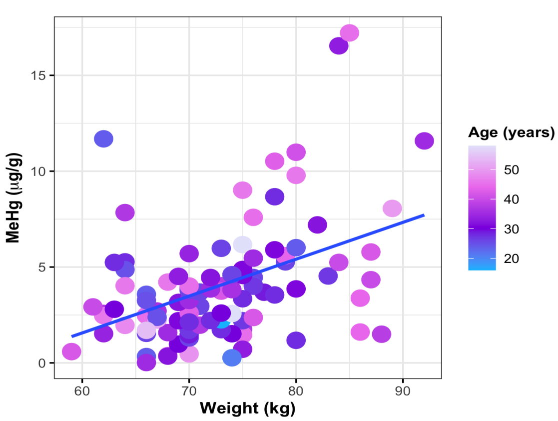

FIGURE 7. Scatter graph plotting `weight` against `MeHg` in terms of `age`

A.7. Residence time in Kuwait

Figure 8 displays two distributions of `age` and `restime`. It is obvious that these variables do not follow a Normal distribution. In Figure 9, the larger the bubble size the larger the `MeHg` levels in μg/g. Though it was expected that the longer the fishermen has lived in Kuwait, the more fish they would eat leading to higher methylmercury concentration levels, it seems that there is no relationship between `restime` and `MeHg` levels.

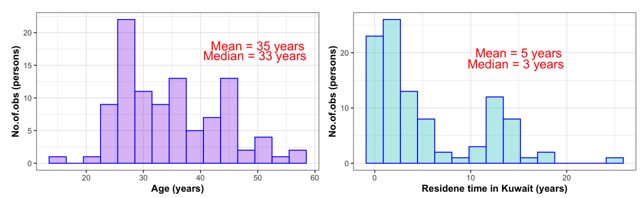

FIGURE 8. Histograms the distributions of `age` (left) and `restime` (right)

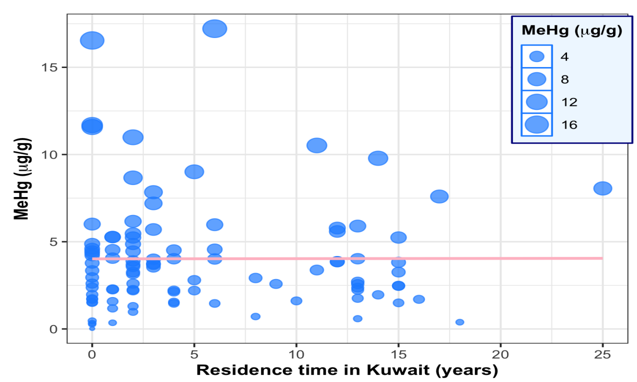

FIGURE 9. Scatter graph plotting residence time in Kuwait against methylmercury concentration in fishermen variable

B. Generalised Linear Model (GLM)

Based on the results of the correlation tests, and by looking at the non-linear relationship between the independent variable of interest `fishmlwk` and the outcome variables `MeHg` and `TotHg` in Figure 10, a Generalised Linear Model seems to be better choice to fit the data than a Multiple Linear Regression model. Given that the data does not follow a Normal distribution and the outcome is a positive continuous variable, GLM having Gamma family is appropriate in this case.

The aim of constructing such model is to determine which variable has a significant impact on the mercury levels, predicting-wise. Overall, two GLM models of the same family from Gamma distribution were fitted, one for `MeHg` outcome and one for `TotHg` outcome.

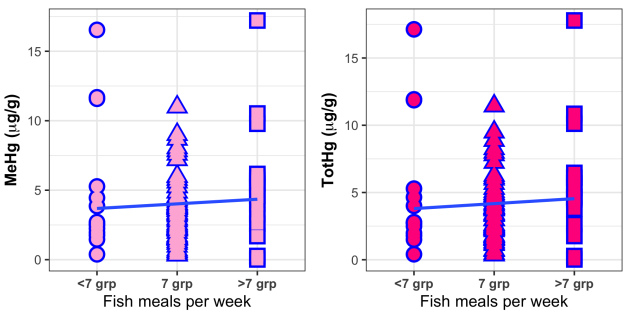

FIGURE 10. Scatter plots of `MeHg` and `TotHg` against `fishmlwk`

B.1. Collinearity diagnosis

It is important to look into the correlation between predictor variables before fitting the model, as correlation can reduce the statistical significance of the predictors.

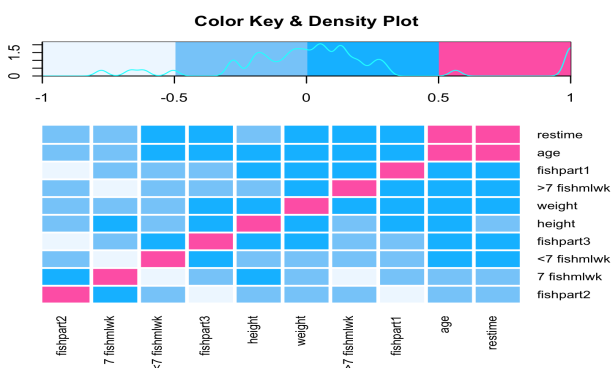

FIGURE 11. Heatmap showing correlation values between independent variables

It seems that `fishmlwk` variable has some moderate correlation in a positive manner with other predictor variables when looking at Figure 11. For example, `<7 fishmlwk` is correlated with `fishpart3`, `restime` and `age`; `7 fishmlwk` is correlated with `fishpart2` and `height`; `>7 fishmlwk` is correlated with `fishpart1`, `weight`, `restime` and `age`. In other words, older fishermen that belong to the least fish consumption group and have lived in Kuwait for longer tend to eat whole fish; taller fishermen tend eat a mixed of muscle and whole fish; older fishermen that belong to the highest fish consumption, have lived in Kuwait for longer and weight more tend to consume only fish muscle.

B.2. Model summary

For an identity link function, and assuming that all the predictor variables are 0, the structure of the model implies:

$$\mu_i = E[y_i] = \text{Intercept}$$

which is an invalid value of μ if the intercept is negative (the outcome variable must be a real positive number). Therefore, an inverse link was used instead of a identity link for the Gamma model. The full model is then:

$$\frac{1}{\mu_i} = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6$$

for i = 1, ..., 100 where β_0 is the intercept/baseline representing fishermen belonging to the "least fish consumption per week and only consume fish muscles" group, and

- X_1 - `fishmlwk`
- X_2 - `fishpart`
- X_3 - `weight`
- X_4 - `height`
- X_5 - `age`
- X_6 - `restime`

IV. Results

In this section, several GLM Gamma models were fitted and their coefficients were observed for `MeHg` and `TotHg` variables. The best models were selected using Akaike Information Criterion (AIC) amongst the candidate models. Residual diagnostics were then performed on the selected models in order to check for the models' reliability.

A. Model Selection

By definition, AIC measures the loss of information as a balanced penalty taking into account how well the model fits the data (based on lack of fit) and the complexity of the model (based on lack of parsimony). The model with the lowest AIC value using backwards elimination method would then be considered the best model.

TABLE 3. AIC results for the models predicting `MeHg`

No.	Model	AIC
Model 1	$\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6$	455.69
Model 2	$\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5$	455.63
Model 3	$\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4$	453.69
Model 4	$\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3$	453.06

X_1 = fishmlwk, X_2 = fishpart, X_3 = weight, X_4 = height, X_5 = age, X_6 = restime

For `MeHg` variable, Model 4 (see Table 3) appears to be the best model with the lowest AIC value. The p-value of the `7 fishmlwk` coefficient is 0.0982 (<0.1) and the p-value of the `weight` coefficient is 0.00002 (<0.001) hence `7 fishmlwk` is significant at 10% level and `weight` is significant at 0.1% level. The other variable coefficients in this model have non-significant p-values.

TABLE 4. AIC results for the models predicting `TotHg`

No.	Model	AIC
Model 1	$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 +$ $\beta_5 X_5 + \beta_6 X_6$	461.95
Model 2	$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$	461.99
Model 3	$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$	460.03
Model 4	$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$	459.26

X_1 = fishmlwk, X_2 = fishpart, X_3 = weight, X_4 = height, X_5 = age, X_6 = restime

For `TotHg` variable, the model with the least variables is also the best model in comparison to the others with the smallest AIC value (see Table 4). `TotHg`'s best model has similar interpretation of coefficients to that for `MeHg` where `weight` and `7 fishmlwk` are significant at 0.1% and 10% levels, respectively and the rest of the coefficients are found to be non-significant.

B. Residual diagnostics of the GLM model

Goodness-of-fit tests for the optimal models were conducted using **DHARMa** R package (*F. Hartig, 2020 [10]*) rather than using classic residual diagnostics plots. This is because the errors from Gamma distribution do not follow a Normal distribution. Figure 12 and Figure 13 examine the residuals' behaviour of the fitted line of the best models, consisting of the **QQ plot** on the left and **residual plot** on the right.

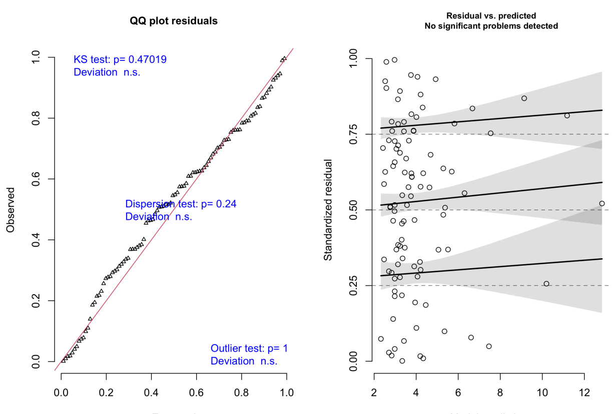

FIGURE 12. DHARMa residual diagnostic plots for `MeHg` data

QQ plot examines overall deviations from the expected Uniform distribution and also test for uniformity, overdispersion and outliers. For both outcome variables, the p-value obtained from the Kolmogorov-smirnov (KS) test implied that the residuals follow the (flat) Uniform distribution and the residual plot also showed that there are no obvious pattern in the residuals. Note that there is one simulated outlier (data points that are outside the range of simulated values) in the residual plot for `TotHg` (see Figure 13), but since the outlier test's result is non-significant, this outlier shouldn't be a major concern. The dispersion test returned non-significant results and seemed to indicate there is no overdispersion for both variables. The result of the outlier test also implies that there are no significant outliers for `MeHg`.

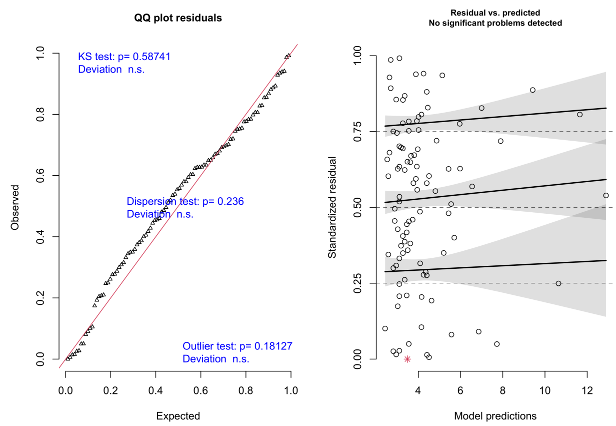

FIGURE 13. DHARMa residual diagnostic plots for `TotHg` data

V. Discussion

In the preliminary analysis stage, the mean of `MeHg` and `TotHg` were reported to be 4.02461μg/g and 4.18083μg/g, respectively. The median of `MeHg` is 3.461μg/g and the median of `TotHg` is 3.7315μ/g. The two outcome variables' correlation was analysed using a Spearman's rank correlation test, due to their extreme outliers and skewed distribution. The result found to be highly correlated, hence correlation analysis between the independent and the dependent variables was only done on `MeHg` levels. The correlation tests has found that only `weight` is significantly correlated to mercury levels, and that `height` is also correlated to mercury levels at 10% significance level.

Both Generalised linear models for `MeHg` and `TotHg` concluded with the same results. The best models were selected using AIC backwards elimination, and inspected using residual diagnostic tests relevant to the residual assumptions of the Uniform distribution. `weight` again was found to have a significant impact on the mercury levels in the predictive model. In saying that, it is with evidence that the more the fishermen weigh, the higher the mercury levels found in their hair, given that the fisherman's main diet is fish.

Based on the GLM results, `7 fishmlwk` is statistically significant at 10% level, implying that the relationship between fishermen who consume 7 fish meals per week and mercury levels is significant. Since fish meals per week variable before processing is not clearly defined (is "3" categorized for three fish meals per week or is it three fish per meal per week, and so on), it is not a good representative of the independent variable of interest which is the amount of fish consumed. In this report, I am assuming `fishmlwk` is categorized as number of meals per week that included fish. Even so, the fishermen could consume more than just one fish per meal. For example, for `fishmlwk = 7 grp` some fishermen could have a lot of fish per meal, whereas other fishermen in the `fishmlwk = >7 grp` could have a lot less fish per meal and the fish amount from each meal can vary.

The amount of fish consumed is also dependent on the amount of edible parts of fish eaten and type of fish. Hence even if some fishermen consume lots of fish per week, but the fish they are eating is the type with the least mecury concentration levels and the fish parts they eat also contains the least mercury concentration levels then their observed mercury levels will be low.

Another reason why `fishmlwk` was found not to be strongly related to mercury levels as expected could be because there are no drastically significant differences between the `fishmlwk` groups as shown in the preliminary analysis stage. In other words, the mercury concentration levels of the lowest consumption group was expected to be smaller than the mercury levels of the highest consumption group but it is not the case when looking at each observation individually. For example, one fisherman in group 1, their `TotHg` level is 11.863μg/g which is suspiciously high for a low fish consumption group. Additionally, the strong correlation between the predictors might have reduced the statistical significance of the `fishmlwk` variable. In particular, the findings of the heatmap visualization showed that `<7 fishmlwk` is correlated with `fishpart3`; `7 fishmlwk` is correlated with `fishpart2` and `>7 fishmlwk` is correlated with `fishpart1`.

A couple of outliers where values were above 15μg/g were detected in the data. Needless to say, these observations possibly have contributed to violate the linear assumptions between the amount of fish intake and mercury levels. The outliers exist for many possible reasons, data was entered incorrectly, participants giving wrong answers, variability in the population, etc. It also could be because the mercury levels was obtained from other food, rather than fish although it has been established that the fisherman's main diet is fish. I chose not to remove these outliers because I didn't collect the data and was not sure what caused the outliers.

A. Comparison with previous studies

The results of `MeHg` being highly correlated with `TotHg` from this report agrees with *A. Bou-Olaya et al., 1994 [3]*, *F. W. Lipfert et al., 2003 [4]* and *M. M. Storelli et al., 2003 [5]* statistical findings. Methylmecury and total mercury levels were shown to have a linear relationship to the amount of fish intake in fishermen from previous researchs such as *H. Augier et al., 1993 [2]* article and *N. B. Al-Majed et al., 2000 [6]* article, the findings from this report however were found to be significant only for one group of fish meals intake (`fishmlwk = '7 grp'`). Comparison to the *P. Houserova et al., 2006 [6]* study, `fishpart` categories were found not associated with the mercury levels in the present study.

B. Future Research

In the future, it is desired to consider the type of frequently caught fish in Kuwait as one of the predictors to be included in the model used for fitting mercury levels data. This is because different fish species have different mercury concentration levels. It will be interesting to see which type of fish and their edible parts has the most influence on the mercury levels found in fishermen hair.

C. Conclusion

To conclude and answer the research question, the results of the present study show that fish meals per week is related to the mercury levels at 10% significance level, specifically the 7 fish meals per week category for fishermen living in Kuwait. The study also show that there is no relationship between the parts of fish eaten and mercury levels, despite previous findings have shown that there exists a relationship between the two variables. Weight was however discovered to be strongly related to mercury levels based on the correlation tests. From the results of the Generalised Linear Model, fishermen body weight was found to influence the prediction of mercury concentration levels at a 0.1% significance level. Age and residence time in

Kuwait were reported to be not related to the mercury levels. On another note, despite the sample size of fishermen being relatively small, the result is consistent and only reflect on the population in Doha fishing village where the data was obtained from.

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