Annex 1

Annex 1.1: Three steps algorithm to calculate work intensity

The following three-steps algorithm aims to measure the extent of work density.

Step 1: calculate manload:

$$ML_x = \frac{\sum_i^n P_i \times T_i}{LH_{effective}} \tag{1}$$

Where,

ML_x is the manload for worker x and refers to work intensity. When its value is one, it means the worker works at full normal utilization, and higher than one indicates overutilization.

P_i is the productivity of worker x for task i.

T_i is the average cycle time to finish task i

$LH_{effective}$ is the effective labor-hour, including overtime.

Step 2: Define the allowance percentage and decide work intensity:

$$ML_x^+ = \begin{cases} ML_x > 1 + \varphi, 1 \\ Otherwise, 0 \end{cases} \tag{2}$$

Where:

ML_x^+ is the decision variable for high work intensity.

The average cycle time is used in equation (1) since the pace of finishing the task varies across workers. φ is the allowance percentage in manload, which is introduced to handle this variation. Many factors can result in this variation, such as experience, gender, age, and health of workers.

Step 3: calculate the percentage of workers under work intensity

$$Average\ work\ intensity = \frac{\sum_x^n ML_x^+}{n} \tag{3}$$

Annex 1.2: Optimization of Kendall's W using Genetic Algorithm

The objective of the optimization model is maximizing the agreement among raters while maintaining the maximum number of raters. Since the two-rounds Delphi did not result in statistically significant consensus in all categories, the optimization

model also aims to reach statistical significance (see Excel files in the supplements; Genetic Algorithm_Round1.xlsx and Genetic Algorithm_Round2.xlsx).).

The decision variable is y_k which is a binary variable, and k refers to the number of the raters.

The objective function is formulated as following:

$$\max objective = \sum_{q=1}^{9} W_q + \sum_{k=1}^{e} y_k \tag{4}$$

Where,

W_q is Kendall's Coefficient of Concordance for group q, and each group comprises several subjects, and its value ranges between (0 no agreement) and (1 complete agreement). It is a non-parametric statistic that is used to assess the consensus of several raters assessing several u objects. W_q is calculated as follows (Legendre, 2005):

$$W = \frac{12S}{\left(\sum_{k=1}^{21} y_k\right)^2 (u^3 - u) - \left(\sum_{k=1}^{21} y_k\right) T} \tag{5}$$

$$S = \sum_{q}^{u} (R_q - \bar{R})^2 \tag{6}$$

$$R_q = \sum_{k=1}^{e} y_k r_{qk} \tag{1}$$

Where,

r_{qk} is the rating rater k gave to subject q.

R_q is the sum of rating raters gave to subject q.

$\bar{R}$ is the mean of sum ratings given by raters to all subjects.

S is the sum of squares to measure the dispersion of the total rating given for a subject to the average total given to all subjects in a group.

u is the number of subjects to be rated in a group.

T is the correction factor for tied ranks and calculated as follows (Legendre, 2005):

$$T = \sum_{g=1}^{h} (t_g^3 - t_g) \tag{8}$$

Where t_g is the number of tied ranks in each g of h groups of ties. Ties occur when a rater gives a similar rating for at least two subjects.

The constraints are formulated as follows:

Constraint 1: $p - value\ (W_q) \leq 0.05$

Constraint 2: $y_k = \begin{cases} 1 \\ 0 \end{cases}$

If $u \geq 5$ or $(\sum_{k=1}^{21} y_k) > 15$ (Zaiontz, 2019), Friedman's chi-square statistic is computed from W by applying the following formula (Legendre, 2010):

$$\chi^2 = (\sum_{k=1}^{21} y_k)\,(u - 1)W \qquad (9)$$

$p - value$ is calculated in Excel by applying the following function (Zaiontz, 2019):

$$p - value = \text{CHIDIST}\ (\chi^2, u - 1) \qquad (10)$$

Since the objective function is not linear, GA is used to search for a good solution. GA is an optimization search heuristic that mimics the theory of natural evolution where the fittest individuals are selected to produce offspring that inherit the characteristics (in the form of chromosomes and genes) of parents and convey them to the next generations to ensure their survival.

To explain how Kendall's W and p-value can be calculated using Excel, the table below shows the ratings given by the 21 experts in Delphi round-one regarding the importance of dimensions to work decency—using a scale of 1-5. Where 1 means least important and 5 means extremely important. Before applying the optimization algorithm, ratings from all raters are included (Table A1). This is an illustration of how to compute Kendall's W and not to illustrate the iterations of the GA.

Table A1: Ratings given by experts in Delphi round one

Rater	Core	Health and safety	Payment	Hours	Contract	Leave	Relations	Welfare
1	5	5	5	5	5	4	3	4
2	5	5	5	5	5	5	4	4
3	4	4	4	4	4	4	4	4
4	5	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	5	5	4	4	4	3	4	4
7	5	5	5	4	5	5	4	5
8	5	5	5	5	4	4	4	4
9	5	4	5	4	5	4	4	4
10	5	5	5	5	4	4	4	4
11	4	4	5	5	2	5	3	5
12	5	5	4	4	3	4	2	2
13	5	5	5	5	5	5	4	5
14	5	5	5	4	3	3	3	2
15	4	5	4	4	4	4	4	4
16	5	5	5	5	5	5	4	4
17	5	5	5	5	5	5	4	4
18	5	4	3	3	3	3	3	3
19	5	5	5	5	5	4	4	4
20	5	5	5	4	4	5	4	4
21	5	5	5	5	5	5	4	4

Equation (6) assumes that raters rates subjects in rank order. So, the sum of the ratings for each rater should be the same. Calculating the sum of ratings for each rater as follows:

{36,38,32,33,40,33,38,36,35,36,33,29,39,30,33,38,38,27,37,36,38}, respectively for raters.

Since the sum of ratings is not equal, the transformation of the ratings to ranked order is necessary.

For rater 1, ratings are ordered from smallest to largest as follows:

3,4,4,5,5,5,5,5

Transform to ordered ranks as follows:

1,2.5,2.5,6,6,6,6,6

Ranks for subjects 6 and 8 (leave and welfare respectively) is calculated as the average rank as follows:

$$average\ rank = \frac{2+3}{2} = 2.5$$

Similarly, for subjects with rating 6, $average\ rank = \frac{4+5+6+7+8}{5} = 6$

In Excel, the function RANK.AVG is applied to transform ratings into average ordered ranks. The transformed table is shown below.

Table A2: The transformed ratings after applying average rank method

Rater	Core	Health and safety	Payment	Hours	Contract	Leave	Relations	Welfare
1	6	6	6	6	6	2.5	1	2.5
2	5.5	5.5	5.5	5.5	5.5	5.5	1.5	1.5
3	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
4	8	4	4	4	4	4	4	4
5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
6	7.5	7.5	4	4	4	1	4	4
7	5.5	5.5	5.5	1.5	5.5	5.5	1.5	5.5
8	6.5	6.5	6.5	6.5	2.5	2.5	2.5	2.5
9	7	3	7	3	7	3	3	3
10	6.5	6.5	6.5	6.5	2.5	2.5	2.5	2.5
11	3.5	3.5	6.5	6.5	1	6.5	2	6.5
12	7.5	7.5	5	5	3	5	1.5	1.5
13	5	5	5	5	5	5	1	5
14	7	7	7	5	3	3	3	1
15	4	8	4	4	4	4	4	4
16	5.5	5.5	5.5	5.5	5.5	5.5	1.5	1.5
17	5.5	5.5	5.5	5.5	5.5	5.5	1.5	1.5
18	8	7	3.5	3.5	3.5	3.5	3.5	3.5
19	6	6	6	6	6	2	2	2
20	6.5	6.5	6.5	2.5	2.5	6.5	2.5	2.5
21	5.5	5.5	5.5	5.5	5.5	5.5	1.5	1.5
R_q	125.5	120.5	114	100	90.5	87.5	53	65

The transformation results in many ties for each rater. Therefore, equation (8) is used to calculate the T value as follows:

For rater 1, there are two groups of ties; 2.5 and 6. Therefore, $g = 2$. Sum of ties for rater 1 is calculated as follows:

$$T_1 = (2^3 - 2) + (5^3 - 5) = 6 + 120 = 126$$

Apply to all raters:

Table A3: Sum of ties for raters

Rater	Sum of ties
T1	126
T2	216
T3	504
T4	336
T5	504
T6	126
T7	216
T8	120
T9	144
T10	120
T11	66
T12	36
T13	336
T14	48
T15	336
T16	216
T17	216
T18	210
T19	144
T20	120
T21	216

$T = sum\ of\ all\ T_k = 4356$

$\bar{R} = 94.5$ (the average of R_q)

$$S = (125.5 - 94.5)^2 + (120.5 - 94.5)^2 + (114 - 94.5)^2 + (100 - 94.5)^2$$
$$+ (90.5 - 94.5)^2 + (87.5 - 94.5)^2 + (53 - 94.5)^2 + (65 - 94.5)^2$$
$$= 4705$$

$$W = \frac{12 \times 4705}{21^2(8^3 - 8) - 21 \times 4356} = 0.431691$$

$\chi^2 = 21 \times (8 - 1) \times 0.431691 = 63.458574$

$p - value = \text{CHIDIST}\ (63.458574, 8 - 1) = 0.00000000003067$

At $\alpha = 0.05$, the null hypothesis is rejected, which states that raters have produced rankings which are independent of each other (Legendre, 2005). When H_0 is rejected, it can be said that at least one rater is concordant with at least one or more raters (Cafiso, Di Graziano and Pappalardo, 2013). SPSS software was used to verify the calculations on Excel.

The table below contains a summary of the GA settings applied using Excel:

- Mutation probability: 0.075 (default)
- Population size: 4,000
- Maximum time without improvement: 100 seconds

The optimization algorithm has been applied to both Delphi rounds. Round one yielded a better solution in terms of maximizing the objective function and satisfying the constraints. The values for the decision variables y_k are as follows:

Table A4: Results of the Genetic Algorithm

y (rater)	Value
rater 1	1
rater 2	1
rater 3	1
rater 4	1
rater 5	1
rater 6	1
rater 7	0
rater 8	1
rater 9	0
rater 10	1
rater 11	1
rater 12	1
rater 13	1
rater 14	1
rater 15	0
rater 16	1
rater 17	1
rater 18	0
rater 19	1
rater 20	1
rater 21	1

Annex 2

Annex 2.1: Comparative analysis of Better Work impact across countries

Based on the results of the synthesis reports issued by Better Work program across different countries. This appendix presents a comparative analysis of the impact of the program in 11 categories as illustrated in Figures B1-B11, which are:

- Working Environment
- Worker Protection
- Worker Accommodation
- Welfare Facilities
- OSH Management System
- Health services and first aid
- Emergency Preparedness
- Chemicals and Hazardous Substances
- Regular Hours
- Overtime
- Leave

For the ease of comparison , the time scale is standardized through conversion into a dimensionless unit such that (1) is January 2018 and (140) is August 2019.
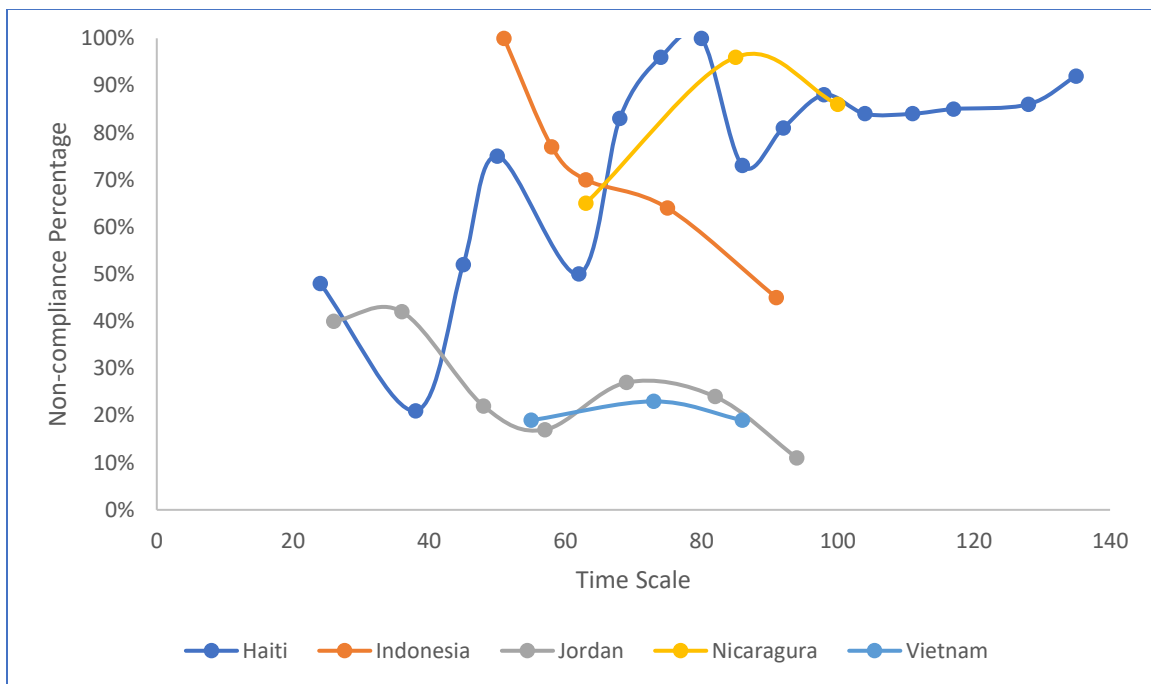
Figure B1: Comparison of BW impact on working environment
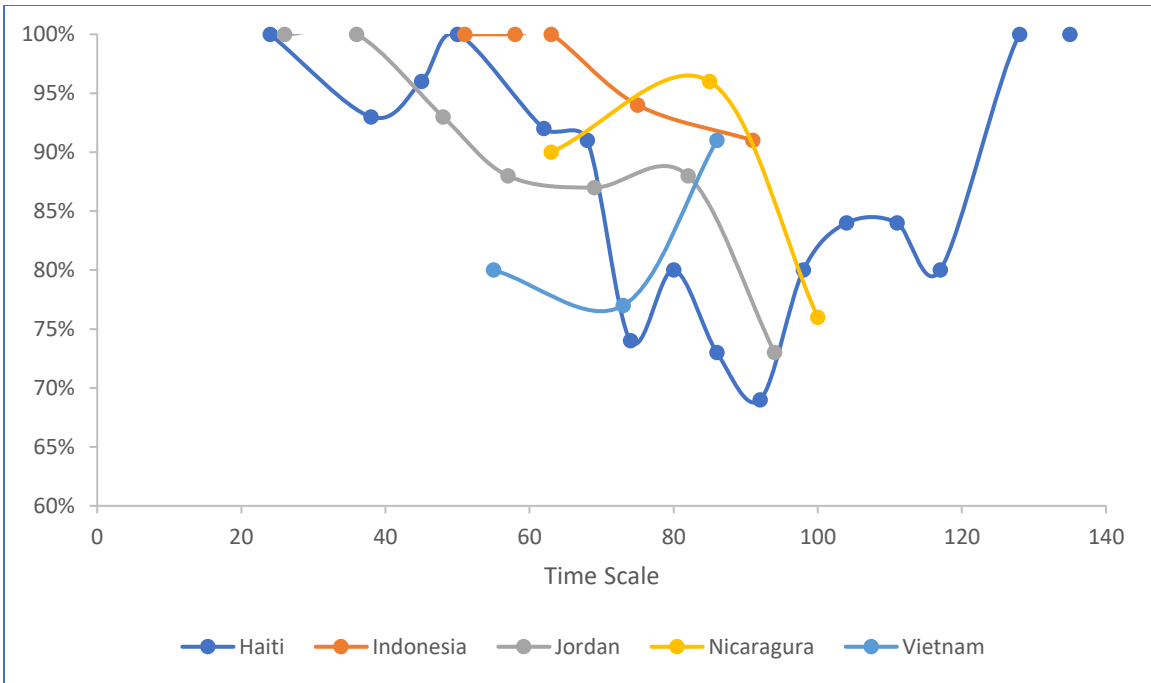
Figure B2: Comparison of BW impact on worker protection
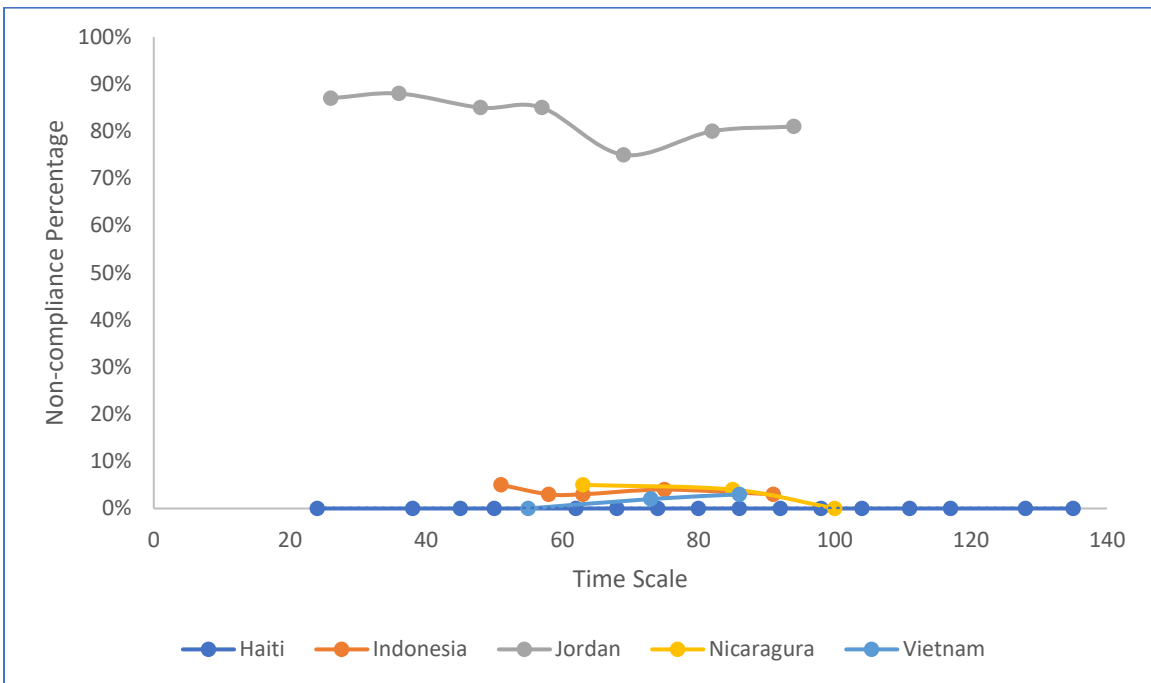
Figure B3: Comparison of BW impact on worker accommodation
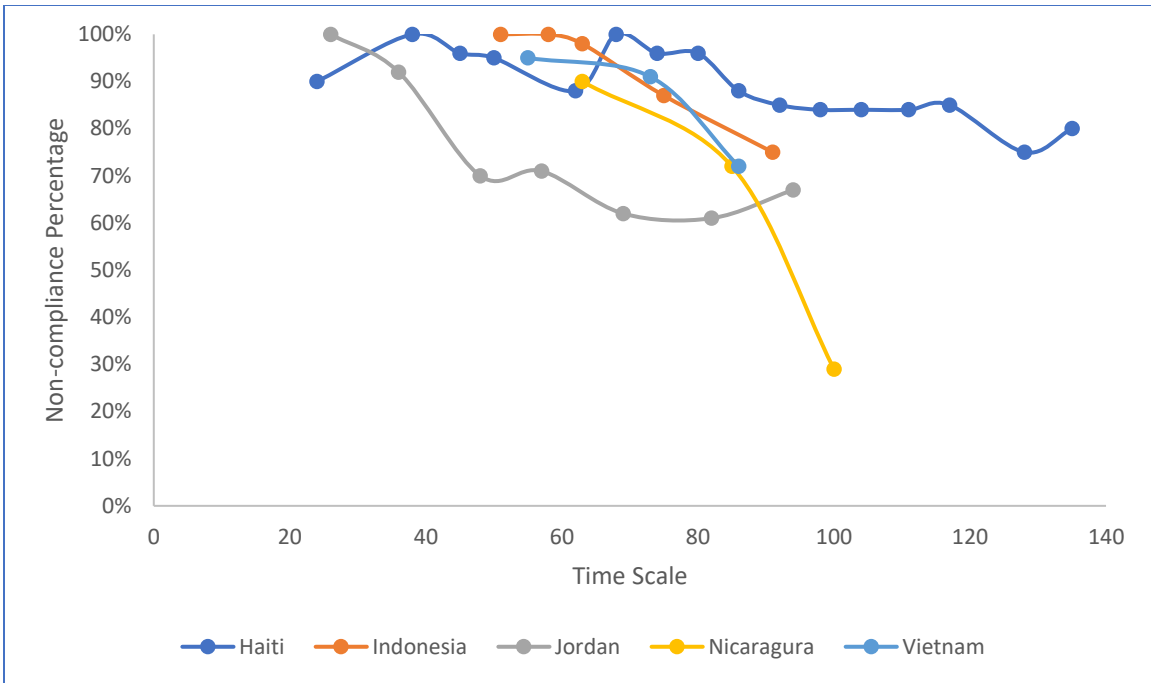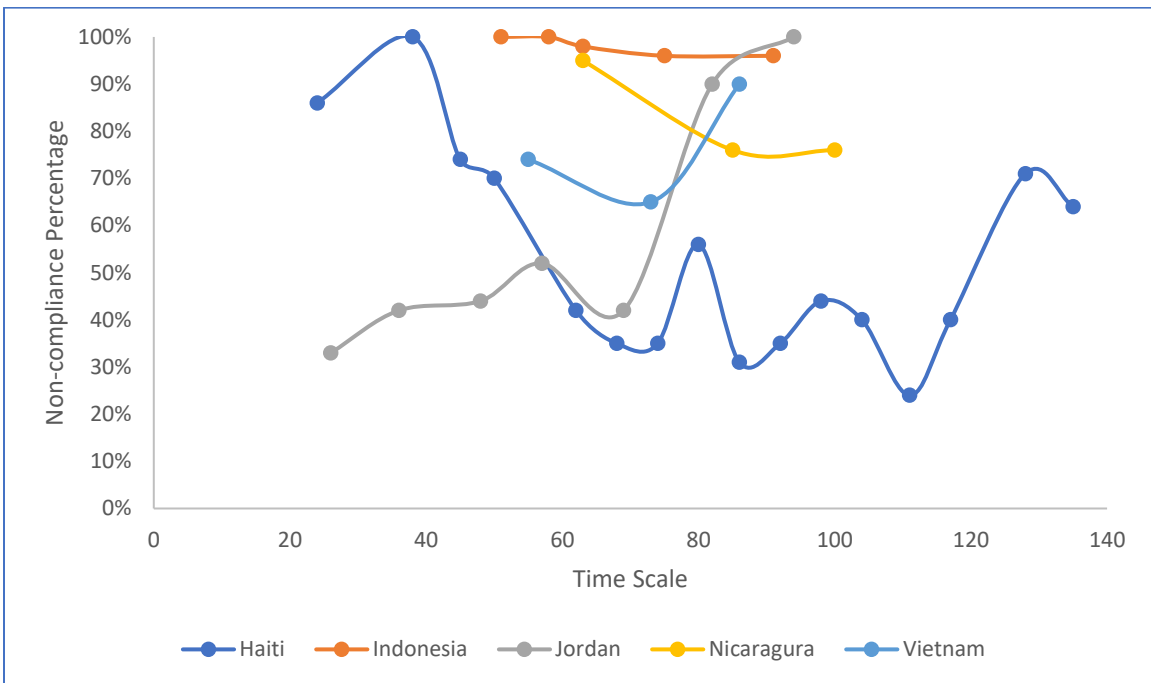
Figure B4: Comparison of BW impact on welfare facilities
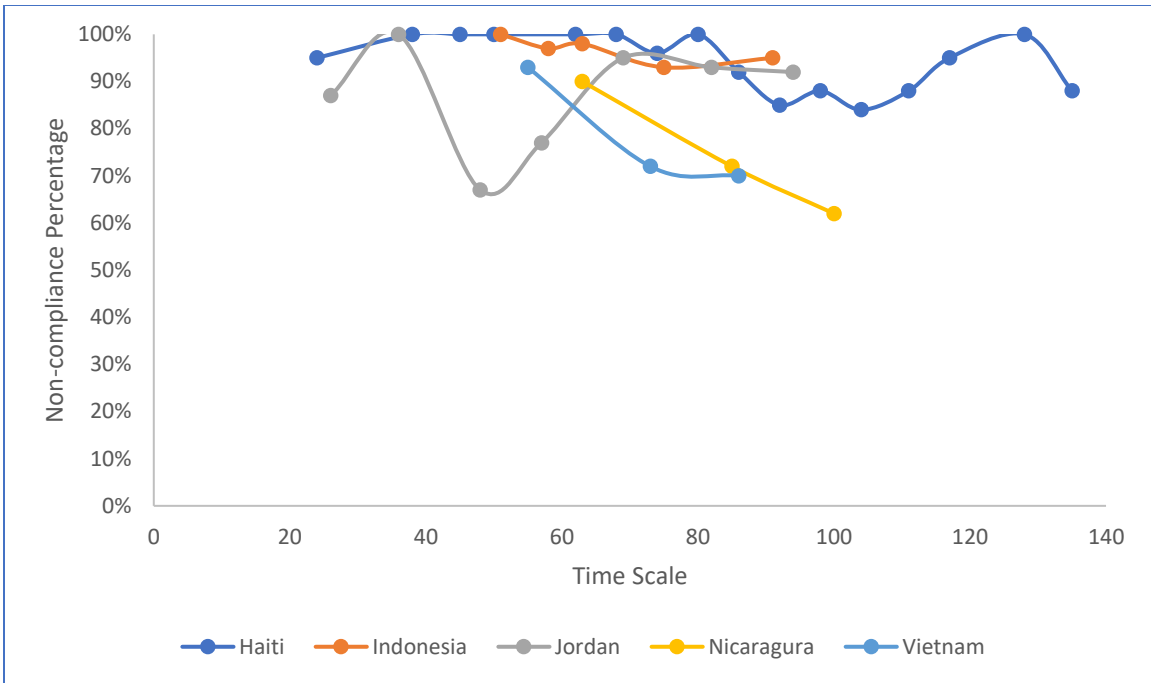

Figure B5: Comparison of BW impact on OSH management system

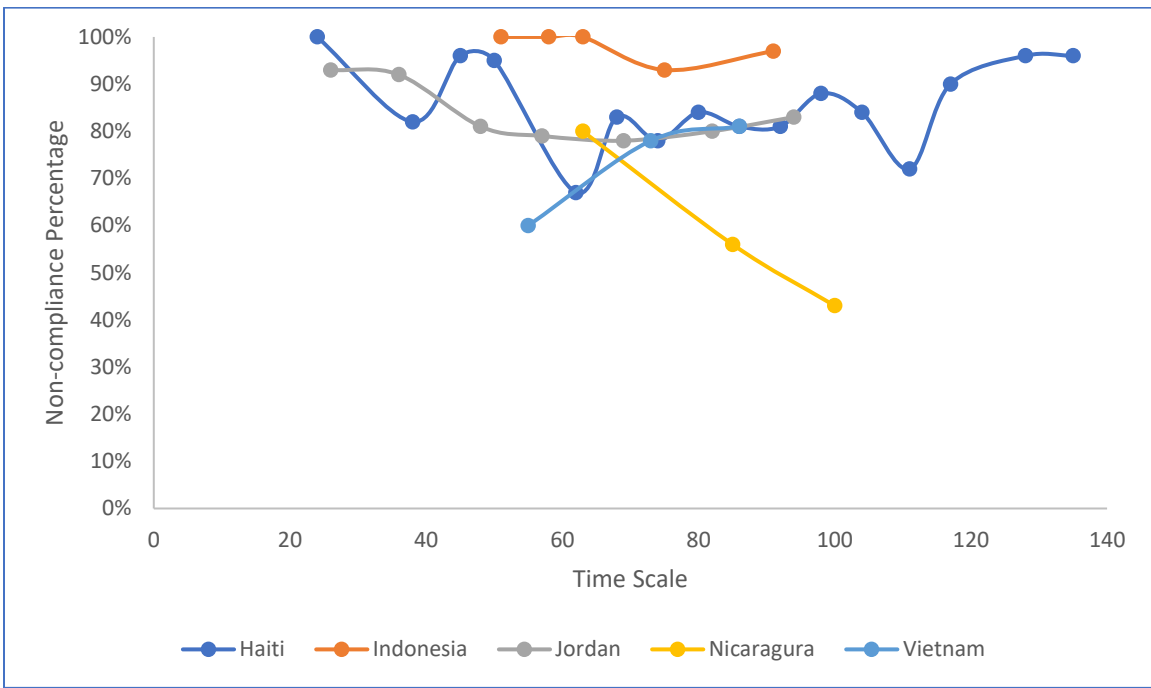**Figure B6: Comparison of BW impact on health services and first aid**

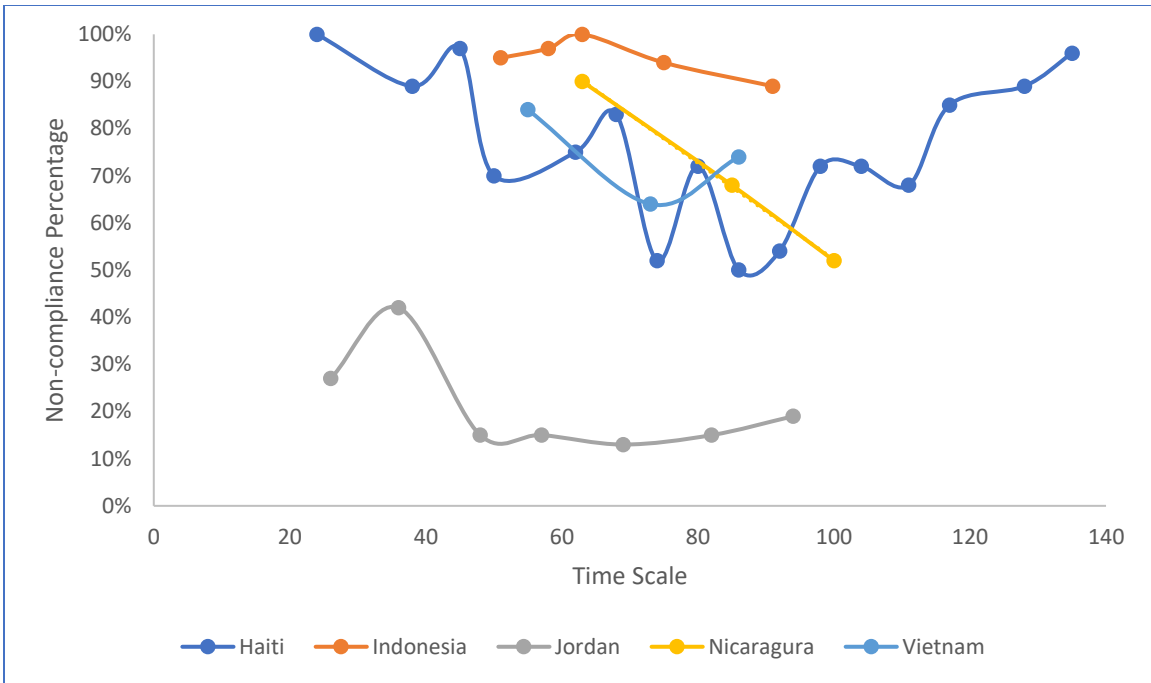*Figure B7: Comparison of BW impact on emergency preparedness*

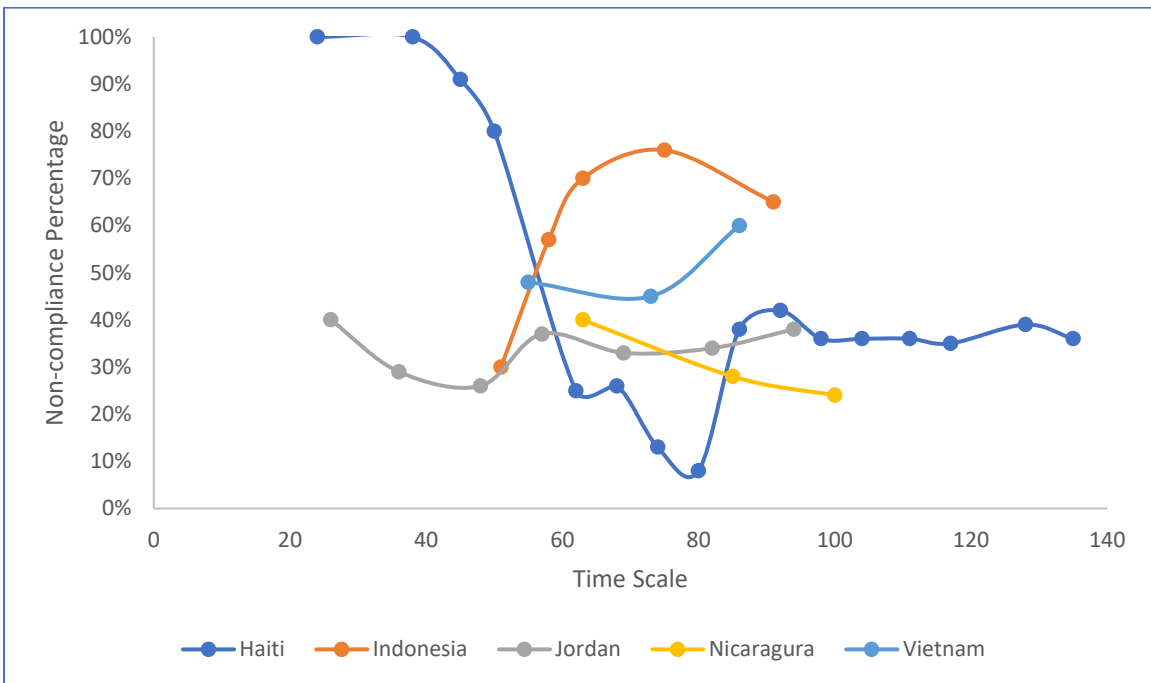***Figure B8: Comparison of BW impact on chemicals and hazardous substances***

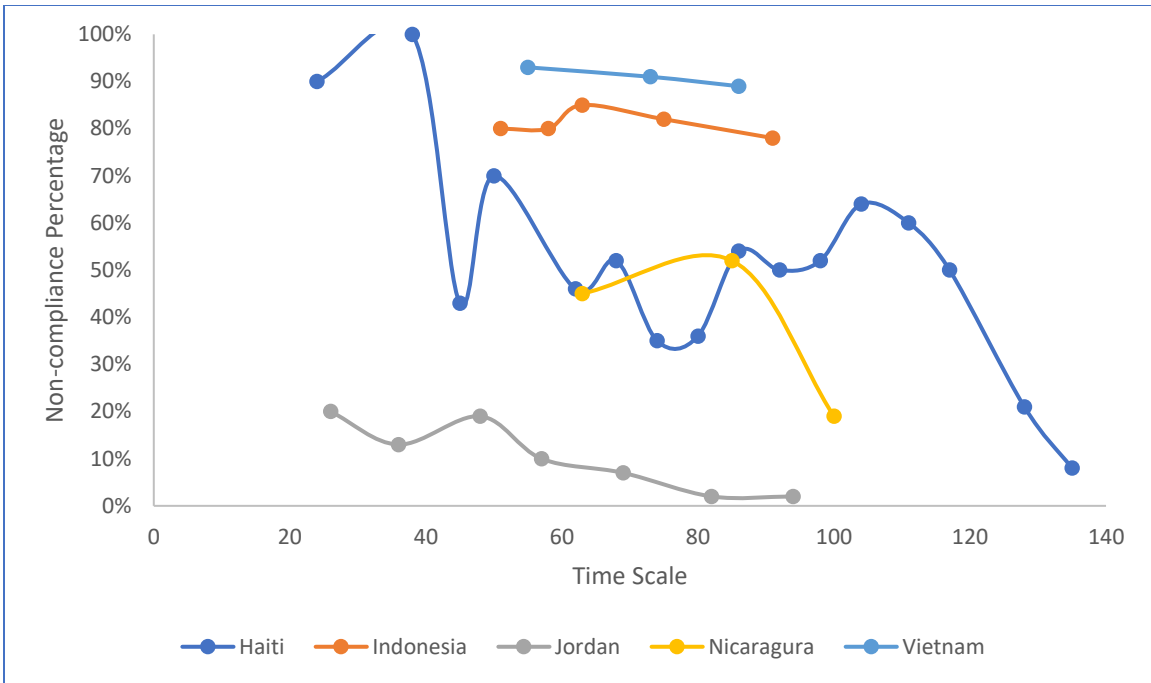***Figure B9: Comparison of BW impact on regular hours***

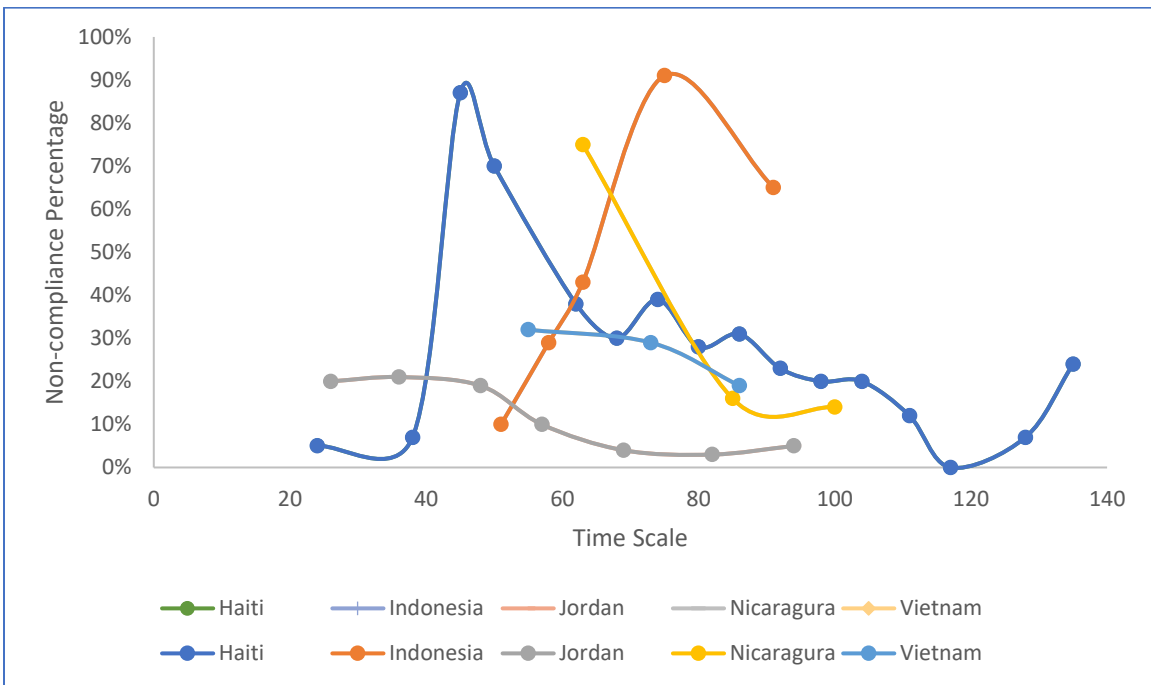*Figure B10: Comparison of BW impact on overtime*

Figure B11: Comparison of BW impact on leaves

References

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Zaiontz, C. (2019) *Kendall's Coefficient of Concordance (W)*. Available at: http://www.real-statistics.com/reliability/interrater-reliability/kendalls-w/ (Accessed: 27 November 2019).