# Increase in metabolic diseases following the Fukushima triple disaster: a retrospective study of Kawauchi Village with long-term follow-up.

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## Background

• On March 11th, 2011, a magnitude 9.0 earthquake struck Japan, leading to a tsunami and radioactive fallout from the Fukushima Daiichi Nuclear Power Plant.

• In response, the Japanese government enacted a mandatory evacuation area in the 20 km surrounding the power plant, forcing nearby residents into government-erected shelters.

• Kawauchi Village is bisected by the mandatory evacuation zone, though there was minimal earthquake damage and radiological exposure. The majority of the village evacuated to shelters in nearby Koriyama City. In April 2012, residents began returning to their homes, and by April 2014 approximately 50% of villagers had returned.

• We aim to evaluate the status of Kawauchi villagers before and after the earthquake and evacuation period, as well as between evacuees and returnees.

• We hypothesized that the disaster would result in both short-term and long-term metabolic sequelae related to the evacuation time period, and that returning to home to Kawauchi Village would, by some alleviation of stress, result in better outcomes.

## Methods

• Each year as part of the standard Japanese National Health Insurance system, the villagers undergo a health screening at Kawauchi Village Health Center.

• We were granted access to this information from 2008 to 2013. Data for 2011 was not available due to the disaster. Measurements taken at evacuation sites were also available.

• Due to a change in the measurement of HbA1c from the Japan Diabetes Society standard to the National Glycohemoglobin Standardization Program Reference Value in 2013, the HbA1c values were shifted accordingly to ensure data comparability.

• As no data was available for 2011, and age-related changes were seen between 2008 and 2010, we used the changes between those years as a baseline for comparison between 2012 and 2013. (Table 2)

• p values of < 0.05 were statistically significant.

## Results

Table 1: Kawauchi Village Health Check Participants

|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| Villagers Present | 777 | 797 | 779 | Disaster | 674 | 576 |
| In Kawauchi | 777 | 797 | 779 |  | 431 | 477 |
| Evacuated (Koriyama City) |  |  |  |  | 184 | 99 |
| Consistently Present (4y) |  |  | 339 |  |  |  |
| Consistently Present (5y) |  |  | 274 |  |  |  |

Table 2: 2008-2010 changes vs. 2010-2012 changes (Population consistent, mean±SD (n) )

|  | 2008 vs. 2010 | 2010 vs. 2012 | p-value |
|---|---|---|---|
| ΔAge | 2.00±0.00 (332) | 2.23±0.42 (332) | <0.001 |
| Gender (M/F) | 156/176 | 156/176 | 1.000 |
| ΔWeight | -0.22±3.28 (323) | 1.15±3.33 (316) | <0.001 |
| ΔBMI | -0.16±0.94 (322) | 0.67±1.41 (316) | <0.001 |
| ΔWaist | 1.33±4.47 (213) | 1.14±5.10 (176) | 0.705 |
| ΔSystolic | 1.15±15.18 (322) | -7.99±17.71 (316) | <0.001 |
| ΔDiastolic | -0.53±10.73 (322) | -2.05±11.06 (316) | 0.079 |
| ΔBlood Glucose | 0.63±11.07 (269) | 4.87±15.17 (262) | <0.001 |
| ΔHbA1c | 0.081±0.237 (316) | 0.050±0.647 (312) | 0.434 |
| ΔHDL | -3.51±7.73 (316) | -2.16±7.62 (311) | 0.029 |
| ΔLDL | -3.41±21.48 (316) | 1.67±26.30 (312) | 0.008 |
| ΔTG | -0.87±39.94 (316) | 4.92±42.39 (311) | 0.079 |
| ΔAST | -1.56±5.65 (316) | 2.91±8.04 (311) | <0.001 |
| ΔALT | -1.54±7.71 (316) | 2.72±10.32 (312) | <0.001 |
| Δγ-GT | -2.30±11.13 (316) | 5.40±20.10 (311) | <0.001 |
| ΔUric Acid | -0.07±0.91 (212) | 0.38±1.05 (207) | <0.001 |

Table 3: Effects of Evacuation on Status Changes

|  | 2012 | | | 2013 | | |
|---|---|---|---|---|---|---|
|  | Kawauchi | Evacuated | p-value | Kawauchi | Evacuated | p-value |
| n | 431 | 184 |  | 477 | 99 |  |
| Weight | 58.45±10.89 (361) | 58.89±11.86 (162) | 0.676 | 58.16±11.56 (399) | 57.93±10.35 (89) | 0.861 |
| ΔWeight | 0.86±3.15 (262) | 1.75±3.78 (87) | 0.030 | -0.55±2.07 (309) | -0.17±1.77 (74) | 0.144 |
| BMI | 24.40±3.61 (361) | 24.88±3.93 (162) | 0.172 | 24.13±3.71 (399) | 24.68±3.17 (89) | 0.195 |
| ΔBMI | 0.55±1.30 (262) | 0.90±1.67(87) | 0.044 | -0.34±0.87 (309) | -0.05±0.83 (74) | 0.012 |
| Systolic BP | 125.44±12.61 (361) | 130.12±17.21 (162) | 0.001 | 126.04±14.80 (399) | 126.83±14.68 (89) | 0.648 |
| ΔSystolic | -9.31±17.39 (262) | -2.94±17.73 (87) | 0.003 | -0.61±15.23 (309) | -2.65±16.02 (74) | 0.305 |
| Diastolic BP | 73.70±8.94 (361) | 76.07±9.09 (162) | 0.005 | 71.27±10.15 (399) | 72.27±8.48 (89) | 0.387 |
| ΔDiastolic | -2.27±10.73 (262) | -0.55±11.25 (87) | 0.201 | -2.99±10.25 (309) | -2.76±10.93 (74) | 0.864 |
| eGFR | 69.28±13.15 (392) | 66.23±13.58 (175) | 0.012 | 65.69±12.75 (438) | 67.18±13.23 (96) | 0.303 |
| Blood Glucose | 100.29±18.86 (321) | 102.02±26.57 (138) | 0.428 | 103.34±18.96 (348) | 103.13±25.30 (77) | 0.933 |
| ΔBl. Glucose | 4.02±13.87 (218) | 8.38±21.72 (72) | 0.049 | 2.59±12.71 (256) | -0.73±18.54 (62) | 0.096 |
| HDL | 57.24±13.91 (361) | 53.54±13.94 (162) | 0.005 | 56.55±13.42 (399) | 57.38±13.83 (89) | 0.599 |
| ΔHDL | -1.64±7.43 (260) | -4.14±7.57 (86) | 0.008 | -0.02±6.87 (309) | 2.32±7.10 (74) | 0.009 |
| LDL | 115.78±29.39 (361) | 117.44±30.18 (162) | 0.554 | 116.81±28.66 (399) | 126.47±33.67 (89) | 0.005 |
| ΔLDL | 1.43±24.50 (260) | 2.21±28.24 (86) | 0.807 | 0.85±23.43 (309) | 3.41±23.83 (74) | 0.401 |
| TG | 96.59±44.87 (361) | 130.51±121.53 (162) | <0.001 | 111.79±74.03 (399) | 101.21±44.68 (89) | 0.196 |
| ΔTG | -1.28±41.99 (260) | 24.50±45.59 (86) | <0.001 | 10.31±58.05 (309) | -14.27±49.24 (74) | 0.001 |
| AST | 26.99±9.95 (361) | 27.49±14.05 (162) | 0.639 | 25.77±9.91 (399) | 24.01±6.71 (89) | 0.112 |
| ΔAST | 2.23±10.73 (262) | 4.62±11.32 (86) | 0.010 | 1.30±8.04 (309) | -3.32±11.18 (74) | 0.025 |
| ALT | 22.10±15.16 (361) | 24.60±20.00 (162) | 0.115 | 22.20±14.73 (399) | 18.06±8.61 (89) | 0.011 |
| ΔALT | 1.67±8.23 (260) | 4.26±13.61 (86) | 0.035 | 0.12±13.59 (309) | -4.92±12.47 (74) | 0.004 |
| Serum Creatinine | 0.76±0.17 (392) | 0.79±0.18 (175) | 0.020 | 0.79±0.18 (438) | 0.76±0.16 (96) | 0.179 |

To conserve space, non-significant changes in parameters are not listed.

• In 2012, age varied slightly due to differences in evaluation month of some patients. (Table 2)

• From **2012 to 2013**, significant differences were seen in **diastolic blood pressure** (74.3 to 71.2, p<0.001), **eGFR** (68.4 to 66.1, p<0.009), and **HbA1c** (5.24 to 5.42, p<0.001).

## Conclusions and Discussion

• Noted increases in metabolic markers in 2012 were seen between the pre-disaster and post-disaster timeframes. This is theorized to be due to decreased exercise secondary to sedentary lifestyle in a shelter, coupled with natural reactions to the stressful environment (increased food consumption, for example; Table 2). These changes were maintained into 2013.

• In 2013, the significant increase in HbA1c vs. previous years following return to the village is concerning, and may demonstrate the effects of ongoing psychological stress on the population. No significant difference was seen between evacuees and returnees in HbA1c. This deserves follow-up and comparison to national Japanese trends for 2013.

• Blood pressure notably declined following the evacuation period. We are still investigating as to why this occurred.

• In 2012, there were notable improvements in health measures for those residents who had returned to Kawauchi: lower systolic BP, diastolic BP, higher HDL, lower TG, implying a significant benefit to returning home post-disaster.

• By 2013 the majority of absolute evacuee differences appear to have normalized, suggesting population adjustment to the evacuation city after two years post-disaster. LDL-C is still elevated and worth followup.

• Evacuation comparison was limited due to small numbers; similarly, analysis was limited by inconsistent recording of parameters for health checks. We have listed the n-values here for reference.

• This represents the first time recovery from an earthquake and tsunami has been complicated by nuclear accident, and ongoing longitudinal study is needed to inform response to future disasters.