Glycated hemoglobin levels among workers who remained in the area evacuated after the Fukushima Daiichi Nuclear Plant disaster

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Abstract

Since the Fukushima Daiichi Nuclear Power Plant disaster in 2011, public health issues in neighboring regions have attracted significant attention. One ongoing debate involves whether the prevalence of diabetes has increased in areas with radioactive contamination or not, as previous studies have revealed inconsistent results. Thus, given that the indirect effects of radiation on public health have been extensively discussed, it is important to evaluate the health statuses of individuals who work in regions with relatively high radiation doses and who are thought to have lived without a major change in lifestyle. The present study aimed to evaluate whether glycated hemoglobin values increased between 2010 and 2016 among a sample of factory (Kikuchi Seisakusho) employees from Iitate village, who continued to work in the factory after the disaster. The results indicated that the post-disaster values for glycated hemoglobin did not significantly exceed those from 2010. This finding may be useful for conducting further studies to examine the effects of radioactive contamination exposure on the risk of developing diabetes.

Key words

glycated hemoglobin, disaster, Fukushima, Great East Japan Earthquake, public health

1. Introduction

After the Great East Earthquake and Fukushima Daiichi Nuclear Power Plant disaster on March 11, 2011 (Brumfiel and Cyranoski, 2011), the Japanese government ordered local residents to evacuate the neighboring cities, villages, and towns (Nomura et al., 2016). While many of the evacuated municipalities were < 20 km from the Daiichi Nuclear Power Plant, some of the municipalities were farther away.

Although Iitate village is approximately 40 km away from the Daiichi plant, it was contaminated with radioactive material due to temporal wind (Kamada et al., 2012; Terada et al., 2012) and evacuation was ordered in April 2011. Most of the 6,000 residents were evacuated, although the government granted special permission for continued operation of three workplaces including "Iitate Home," "Kitahara Shouten," and "Kikuchi Seisakusho" (Sakumi et al., 2016). Thus, approximately 250 employees began commuting from outside Iitate village to the Kikuchi Seisakusho factory to ensure its continued operation.

Previous studies regarding large-scale disasters have revealed associations with increased prevalence of chronic diseases (Inui et al., 1998; Kario, 2012; Kirizuka et al., 1997; Saito et al., 1997). However, existing research regarding health status changes after the Fukushima Daiichi Nuclear Power Plant disaster have revealed inconsistent findings. For example, some studies revealed an increase in the prevalence of diabetes and glycated hemoglobin (HbA1c) values among individuals in contaminated areas (Ebner et al., 2016; Satoh et al., 2015), while another study detected no differences (Ishii et al., 2016). In this context, the importance of effective risk communication in alleviating public anxiety is well recognized (Hasegawa et al., 2016; Shimura et al., 2014; Tamari et al., 2016; Yamaguchi et al., 2018). Therefore, it is crucial to precisely evaluate the health status of residents in areas with radioactive contamination, in order to successfully perform risk communication.

The present study evaluated whether the HbA1c values of the Kikuchi Seisakusho employees changed between 2010 (before the disaster) and 2016 (after the disaster).

2. Materials and Methods

2.1 Subjects

The present study evaluated 103 Kikuchi Seisakusho employees who underwent every annual medical examination during 2010-2016. In other words, the data obtained in 2010 and 2016 from identical employees were used.

2.2 Statistical analysis

The method for measuring HbA1c values (%) defined by Japan Diabetes Society had been used until 2012, and so the values for the present study were converted into the internationally used NGSP values based on the following formula: NGSP (%) = 1.02 × JDS (%) + 0.25 (%) (Kashiwagi et al., 2012). The subjects' descriptive characteristics were obtained, and regression analysis was used to determine whether HbA1c values were affected by age or sex (male sex was coded as 1 and female sex was coded as 0). Analysis of covariance (AN-

COVA) was performed to identify whether there was a difference between 2010 (before the disaster) and 2016 (after the disaster).

3. Results and Discussion

3.1 Subjects' characteristics

Subjects' age, sex, and medical history are presented in Table 1. The employees' average age in 2010 was 34.4 years (*SD* = 10.3 years), with ages ranging from 19 years to 55 years. Five subjects (4.9 %) were 10-19 years old, 35 subjects (34.0 %) were 20-29 years old, 24 subjects (23.3 %) were 30-39 years old, 34 subjects (33.0 %) were 40-49 years old, and 5 subjects (4.9 %) were 50-59 years old. The subjects included 21 women (5.8 %) and 82 men (22.7 %). An evaluation of the employees' medical histories revealed histories of hypertension (10 cases, 9.7%), hyperlipidemia (3 cases, 2.9 %), fatty liver disease (2 cases, 1.9 %), diabetes mellitus (2 cases, 1.9 %), cardiovascular disease (1 case, 1.0 %), and kidney disease (1 case, 1.0 %) as of 2016. Two individuals experienced the onset of diabetes after the disaster, with one patient receiving drug treatment and the other patient being under follow-up medical examination.

Table 1: Subjects' characteristics (*N* = 103)

	n	(%)
Age		
10-19	5	(4.9)
20-29	35	(34.0)
30-39	24	(23.3)
40-49	34	(33.0)
50-59	5	(4.9)
Sex		
Male	82	(22.7)
Female	21	(5.8)
Medical history		
Hypertension	10	(9.7)
Hyperlipidemia	3	(2.9)
Fatty liver disease	2	(1.9)
Cardiovascular disease	1	(1.0)
Kidney disease	1	(1.0)

The annual HbA1c values were 5.24% (*SD* = 0.31 %) in 2010 and 5.28 % (*SD* = 0.46 %) in 2016 (Table 2).

Table 2: Descriptive statistics of HbA1c and Body Mass Index

Year	HbA1c in %		BMI	
	M	(*SD*)	*M*	(*SD*)
2010	5.24	(0.31)	22.81	(3.20)
2011	5.12	(0.35)	23.22	(3.27)
2012	5.23	(0.40)	23.80	(3.59)
2013	5.10	(0.45)	23.75	(3.54)
2014	5.36	(0.63)	24.04	(3.61)
2015	5.30	(0.49)	24.00	(3.61)
2016	5.28	(0.46)	24.05	(3.71)

3.2 ANCOVA results

Before examining the effects of measurement year (2010 vs. 2016) on the HbA1c values, we estimated the effects of sex and age (Figure 1). Regression analyses revealed that age significantly affected the HbA1c values ($\beta = .27$, t (204) = 4.01, $p < .01$), while sex did not have a significant effect ($\beta = -.09$, t (204) = –1.32, $p = .20$). Therefore, the ANCOVA was adjusted for age, which revealed that measurement year did not significantly affect the HbA1c values (F (1, 203) = 0.61, $\eta^2_p < .01$, $p = .43$). The results suggested that, although the subjects' BMI increased slightly between 2010 (22.91 kg/m^2) and 2016 (24.05 kg/m^2), this increase was not sufficient to significantly affect the subjects' HbA1c values or the onset of diabetes.

Furthermore, based on the slightly skewed distribution of the HbA1c values, we repeated the analyses using log-transformed HbA1c values, which revealed that the measurement year still had no significant effect on the log-transformed HbA1c values (F (1, 203) = 0.46, $\eta^2_p < .01$, $p = .50$).

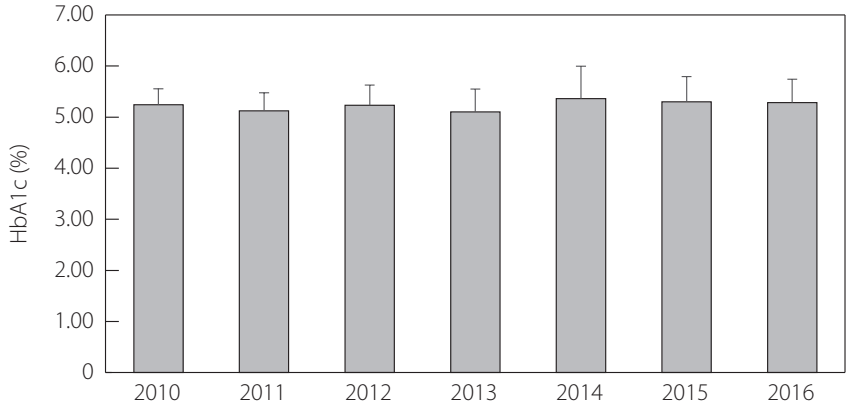

Figure 1: Changes in HbA1c from 2010 to 2016

3.3 Limitations

This study has several limitations. The first limitation concerns the sample selection. That said, employees who left their job were excluded from the analysis, and it is possible that the actual HbA1c values could have been lower than the measured values if these individuals had relatively serious health problems. Second, the prevalence of diabetes is influenced by other social factors, such as income and job type (Tunceli et al., 2005; Weng et al., 2000). Therefore, future studies must control for those factors. Third, as previous research has shown that disaster-related lifestyle changes can influence health status (Hasegawa et al., 2015), further research is needed to explore whether Kikuchi Seisakusho employees experienced lifestyle changes, and whether these changes influenced their health status.

4. Conclusion

By choosing Kikuchi Seisakusho employees, who kept working even after the evacuation order was issued in 2011, for this study, we compared the HbA1c levels between 2010 and 2016. Results of ANCOVA revealed no detectable increase after the 2011 Nuclear Power Plant accident in the HbA1c values among the employees, and an additional analysis using log-transformed HbA1c values yielded identical results. As this finding suggests that continuing their work might have functioned as a protective factor for the exacerbation of HbA1c values, this finding can be useful when risk communication and public health education concerning radioactivity are conducted.

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