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国際シンポジウム事務局（広報・国際連携室）
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2023 Fukushima Medical University International Symposium on the Fukushima Health Management Survey
Secretariat of International Symposium
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Evidence on non-communicable diseases: Lessons from the Fukushima Health Management Survey

SHIMABUKURO Michio, MD, PhD
Department of Diabetes, Endocrinology, and Metabolism, Fukushima Medical University
Office of the Comprehensive Health Check and Health Promotion, Radiation Medical Science Center for the Fukushima Health Management Survey, FMU
1. NCD after the nuclear accident: what we know

2. Estimated radiation dose & NCD

3. Possible mechanisms & prevention

NCD: Non-communicable diseases
NCD after the nuclear accident: what we know in CHC

≤15y: Children

A certain number of children presented with obesity, dyslipidemia, hyperuricemia, liver dysfunction, hypertension, and IGT. Obesity improved in the follow-up survey, but the improvement of lipid abnormalities in boys was delayed.

≥16y

- **Increased**: obesity, metabolic synd, IGT & diabetes, chronic kidney disease, hyperuricemia, and polycythemia

- **Increased but improved**: blood pressure, LDL-cholesterol (residents under treatment increased), liver dysfunction (decreased due to the improvements of daily physical activity and frequency of breakfast intake)

- **No changes**: WBC counts and fractions within the evacuated areas: no direct effects observed

CHC: The Comprehensive Health Checkup
IGT: impaired glucose tolerance

Based on the report submitted to the 41st Prefectural Monitoring Committee Meeting for Fukushima Health Management Survey
Increased NCD after the disaster

≤15y

Obesity

Dyslipidemia

Increased NCD

≥16y

Obesity

Obesity - Metabolic synd

Visceral Obesity → High TG Low HDL → Hypertension → IGT

CKD, Stroke, Heart attack

Heart failure, AFib, Dementia, Cancer

Diabetes

Smoking LDL chol Hyper-tension IGT

IGT: impaired glucose tolerance
CKD: chronic kidney disease
AFib: atrial fibrillation
Tanabe ... Shimabukuro, Diabetes Res Clin Pract 2021  
4
Agenda

1. NCD after the nuclear accident: what we know

2. Estimated radiation dose & NCD

3. Possible mechanisms & prevention

NCD: Non-communicable diseases
FHMS includes 5 surveys

1. Basic Survey
2. Thyroid Ultrasound Examination
3. CHC
4. Mental Health and Lifestyle Survey
5. Pregnancy and Birth Survey

CHC: Comprehensive Health Check
FHMS: Fukushima Health Management Survey

From website of the Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University
Estimated radiation dose & NCD

Backgrounds

• Basic survey in the Fukushima Health Management Survey
  • Four months after 2011 Great East Japan Earthquake (GEJE) and the subsequent accidents at the Fukushima Daiichi Nuclear Power Plant (FDNPP) March 11, 2011 to July 11, 2011
  • Estimated radiation doses were determined in all Fukushima residents (Yasumura S et al., 2012)

Purpose

• To determine the relationship between estimated radiation dose and NCD in residents who underwent CHC of FHMS in 2011
• Sakai et al, J Epidemiol 2022:32 (Suppl_XII);S84.

CHC: Comprehensive Health Check
FHMS: Fukushima Health Management Survey
NCD: Non-communicable diseases
Methods

- Residents who had lived in the area surrounding FDNPP and were forced to evacuate by government order after the disaster, and those who have received CHC.

- Participants in CHC 2011, n=72,869 (Men 31,982, Women 40,887) (≥16y, 30.9%) 16-84y, 54,087 (Men 22,599, Women 31,488).

- Of the above, 52.5% participated in the Basic Survey. For non-participants, radiation doses were estimated with multiple imputation (age, sex and areas).

- Residents were categorized to 0-1 (≥0 and <1), 1-2 (≥1 and <2), and ≥2 mSv/y groups.

- With 2011 as a baseline, onsets of NCS from 2012 to 2017 as hazard ratios (95% confidential intervals, CI).

- Hazard ratio (95% CI) were calculated as for 1 mSv/y as reference in a Cox proportional hazards model.

CHC: Comprehensive Health Check
FHMS: Fukushima Health Management Survey
NCD: Non-communicable diseases

Evacuation zone on 2011 April 22, Fukushima government HP
Results: estimated radiation dose

- Residents who participated in the Basic Survey (obtained estimated radiation doses) (n=28,402, 52.5%)
  - 0-1 mSv: n=19,238 (67.7%)
  - 1-2 mSv: n=7,089 (25.0%)
  - ≥2 mSv: n=2,075 (7.3%)

- Residents who did not participated in the Basic Survey (47.5%) (calculated estimated doses with multiple imputation)
  - 0-1 mSv: 67.5%
  - 1-2 mSv: 24.6%
  - ≥2 mSv: 7.9%

- Distribution: a similar tendency between the above two group

- Analyses were done for the Basic Survey + the non-Basic Survey groups, and the Basic Survey group alone.
## Increased NCD in estimated radiation dose ≥2mSv/y group

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2a</th>
<th>Model 2b</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjusted for</strong></td>
<td>Sex, Age</td>
<td>Sex, Age, BMI</td>
<td>Sex, Age, Evacuation</td>
<td>Sex, Age, BMI, Evacuation</td>
<td>All parameters*</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.29 (1.16-1.44)</td>
<td>1.20 (1.08-1.33)</td>
<td>1.22 (1.09-1.36)</td>
<td>1.13 (1.01-1.26)</td>
<td>1.09 (0.98-1.22)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.17 (1.02-1.36)</td>
<td>1.06 (0.92-1.36)</td>
<td>1.09 (0.94-1.27)</td>
<td>1.00 (0.86-1.16)</td>
<td>1.01 (0.87-1.18)</td>
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<tr>
<td>Dyslipidemia</td>
<td>1.28 (1.04-1.57)</td>
<td>1.20 (0.98-1.46)</td>
<td>1.19 (0.95-1.47)</td>
<td>1.12 (0.90-1.39)</td>
<td>1.13 (0.91-1.40)</td>
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<tr>
<td>Chronic kidney disease</td>
<td>1.04 (0.95-1.13)</td>
<td>1.01 (0.92-1.10)</td>
<td>0.99 (0.90-1.08)</td>
<td>0.96 (0.88-1.06)</td>
<td>1.04 (0.95-1.14)</td>
</tr>
<tr>
<td>Hyperuricemia</td>
<td>1.16 (1.04-1.29)</td>
<td>1.09 (0.98-1.22)</td>
<td>1.11 (0.99-1.24)</td>
<td>1.05 (0.94-1.18)</td>
<td>1.08 (0.96-1.20)</td>
</tr>
<tr>
<td>Liver dysfunction</td>
<td>1.17 (1.06-1.29)</td>
<td>1.13 (1.03-1.24)</td>
<td>1.08 (0.98-1.19)</td>
<td>1.05 (0.95-1.15)</td>
<td>1.06 (0.96-1.17)</td>
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<tr>
<td>Polycythemia</td>
<td>1.32 (1.02-1.71)</td>
<td></td>
<td></td>
<td></td>
<td>1.07 (0.82-1.39)</td>
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<tr>
<td>Anemia</td>
<td>0.88 (0.77-1.01)</td>
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<td></td>
<td></td>
<td>1.14 (0.99-1.31)</td>
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<tr>
<td>Thrombocytopenia</td>
<td>0.95 (0.74-1.23)</td>
<td></td>
<td></td>
<td></td>
<td>1.01 (0.78-1.32)</td>
</tr>
<tr>
<td>Lymphocytopenia</td>
<td>0.91 (0.73-1.15)</td>
<td></td>
<td></td>
<td></td>
<td>0.95 (0.75-1.20)</td>
</tr>
<tr>
<td>Neutropenia</td>
<td>1.08 (0.86-1.36)</td>
<td></td>
<td></td>
<td></td>
<td>1.21 (0.96-1.53)</td>
</tr>
</tbody>
</table>

Numbers are hazard ratios (95% confidential interval) as values with 1 mSv/y as reference in a Cox proportional hazards model.
Summary

- Estimated doses (>2 mSv/yr) were associated with increased hypertension, diabetes, dyslipidemia, hyperuricemia, liver dysfunction, and polycythemia in an age- and sex-adjusted model. However, the association disappeared after adjustment for evacuation status and lifestyle-related factors.
- It is unlikely that the high estimated radiation doses of the evacuees during the first four months after the accident were directly related to the onset of lifestyle-related diseases.
- Meanwhile, it is presumed that evacuation and lifestyle changes have affected the development of NCD among residents with higher estimated radiation doses.

Limitation

- Covered population low in the Basic Survey (30%) could not be representative of the population as a whole. However, post–multiple completion data showed the same results.
- Since CHC was initiated several months after the accident, they may not reflect the effects of radiation exposure during the acute phase.
- The maximum follow-up period for this study was 6 years; longer follow-up is needed to determine the true effect of radiation on NCD.
- The effects of diet, physical activity, and psychological stress were not examined in this study.
1. NCD after the nuclear accident: what we know

2. Estimated radiation dose & NCD

3. Possible mechanisms & prevention

NCD: Non-communicable diseases
### How NCD Occurs

<table>
<thead>
<tr>
<th>Socio-economic &amp; environmental risk factors</th>
<th>Behavioral risk factors</th>
<th>NCD Non-communicable diseases</th>
<th>Complications &amp; Comorbidities</th>
<th>NCD-related disabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globalization</td>
<td>Smoking</td>
<td>Obesity/Metabolic syndrome</td>
<td>Chronic kidney disease</td>
<td>Decline in physical and mental functions</td>
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<tr>
<td>Urbanization</td>
<td>Unhealthy diet</td>
<td>Hypertension</td>
<td>Stroke, Heart attack</td>
<td>Decline in QOL</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Physical inactivity</td>
<td>IGT/Diabetes</td>
<td>Heart failure</td>
<td>Shortening in healthy life expectancy &amp; life expectancy</td>
</tr>
<tr>
<td>Poverty</td>
<td>Healthy alcohol</td>
<td>Dyslipidemia</td>
<td>Atrial fibrillation</td>
<td></td>
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<tr>
<td>Poor education</td>
<td>consumption</td>
<td>(LDL cholesterol, triglycerides)</td>
<td>Dementia</td>
<td></td>
</tr>
<tr>
<td>Inequality</td>
<td></td>
<td></td>
<td>Cancer</td>
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<td>Stress</td>
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<tr>
<td>Discrimination</td>
<td></td>
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</tr>
</tbody>
</table>

### Genetic & Epigenetic risk factors

- Decline in physical and mental functions
- Decline in QOL
- Shortening in healthy life expectancy & life expectancy

Dans et al, Lancet 2021:377;680
Modified by Shimabukuro
Lifestyle- and disaster-related factors and NCD risk: CHC 7y ≥40y, men 10,120, women 13,961

<table>
<thead>
<tr>
<th></th>
<th>obesity</th>
<th>leanness</th>
<th>Hypertension</th>
<th>Diabetes mellitus</th>
<th>Dyslipidemia</th>
<th>Liver dysfunction</th>
<th>CKD</th>
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</thead>
<tbody>
<tr>
<td>Aging</td>
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<td>Obesity</td>
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<td>Leanness</td>
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<td>Exercise ≥ 2x/w</td>
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<tr>
<td>Sleep satisfaction</td>
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<td>EtOH &lt; 40g/d</td>
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<tr>
<td>EtOH ≥ 40g/d</td>
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<tr>
<td>Current smoking</td>
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<tr>
<td>Evacuation</td>
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<tr>
<td>Change of jobs</td>
<td>↑ ↑</td>
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<td>↑ ↑</td>
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<td>Depressive symptoms</td>
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<td>PTSD symptoms</td>
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<tr>
<td>Radiation concerns</td>
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<tr>
<td>Participation in recreation</td>
<td>↓ ↑</td>
<td>↓ ↑</td>
<td>— — — — — —</td>
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</tr>
</tbody>
</table>

Based on the report submitted to the 41st Prefectural Monitoring Committee Meeting for Fukushima Health Management Survey
Increased NCD after the disaster: Evidence for Prevention and Treatment

Scientifically proven facts

- Unhealthy diet
- Physical inactivity

Obesity

- Visceral Obesity
- High TG
- Low HDL
- Hyper-tension
- IGT

Obesity-Metabolic synd

CKD, Stroke/Heart attack, Heart failure, AFib, Dementia, Cancer

Diabetes

Smoking

LDL chol

Hyper-tension

IGT

Unhealthy diet

Physical inactivity

Evidence for Prev & Tr

© Effective

△ Almost not effective

- Not effective

- BW reduction

- Medication

- Motivation

- BW reduction

- Medication

- Salt restriction

- Medication

Non-Obese

Tanabe ... Shimabukuro, Diabetes Res Clin Pract 2021

IGT: impaired glucose tolerance

CKD: chronic kidney disease

Afib: atrial fibrillation
NCD: Who and how to prevent it

How NCD Occurs

- Socio-economic and environmental risk factors
  - Globalisation
  - Urbanisation
  - Air pollution
  - Poverty
  - Poor education
  - Income inequality
  - Stress
  - Discrimination

- Behavioral risk factors
  - Smoking
  - Unhealthy diet
  - Physical inactivity
  - Heavy alcohol consumption

- NCD non-communicable diseases
  - Obesity/Metabolic syndrome
  - Hypertension
  - IGT/Diabetes
  - Dyslipidemia
  - (HDL cholesterol, triglycerides)

- Complications & Comorbidities
  - Chronic kidney disease
  - Stroke, Heart attack
  - Heart failure
  - Atrial fibrillation
  - Dementia
  - Cancer

- NCD-related disabilities
  - Decline in physical and mental functions
  - Decline in QoL
  - Shortening in healthy life expectancy
  - Life expectancy

Role of CHC

- Health policy development and implementation
- Supporting NCD research
- Monitoring of NCD
- Support for national and international cooperation

- Budget for health promotion system (health screening opportunities)
- Research support
- Develop sustained primary health care system

- Offer healthy food
- Offer places and times for physical activity
- Creating systems to support NCD prevention and care services

Global level
- UN, WHO

Country level
- Government, Ministry

Community level
- Local government, community, workplace, school, non-governmental organization (NPO, NGO)

Individual level
- Individual, Family

- Healthy lifestyle
- Health literacy

Budreviciute et al. Front Public Health
2020:574111 Modified by Shimabukuro (Private opinion)

CHC: Comprehensive Health Check
Summary
take home message

1. NCD after the nuclear accident
   • Increased in adult, partially in children: obesity, metabolic synd, IGT & diabetes, chronic kidney disease, hyperuricemia, and polycythemia.

2. Estimated radiation dose & NCD
   • Estimated doses were associated with increased NCD → Presumably, evacuation and lifestyle changes may have affected the development of NCD among residents with higher estimated radiation doses.

3. Possible mechanisms & Prevention
   • After the accident, evacuation and lifestyle changes → unhealthy diet, physical inactivity, and smoking & drinking → mental problem → obesity accompanying NCD are increasing.
   • Individuals (> community, country, and global) learn true health knowledge (=evidence) and commit evidence -based prevention and treatment of NCD.

NCD: Non-communicable diseases
Thank you for your attention

Fukushima Medical University gardens
photos by Shimabukuro
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