

Thyroid Disease among A-bomb Survivors Exposed in Childhood

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Atomic Bomb Survivor Study Overview

A-bomb Study Characteristics

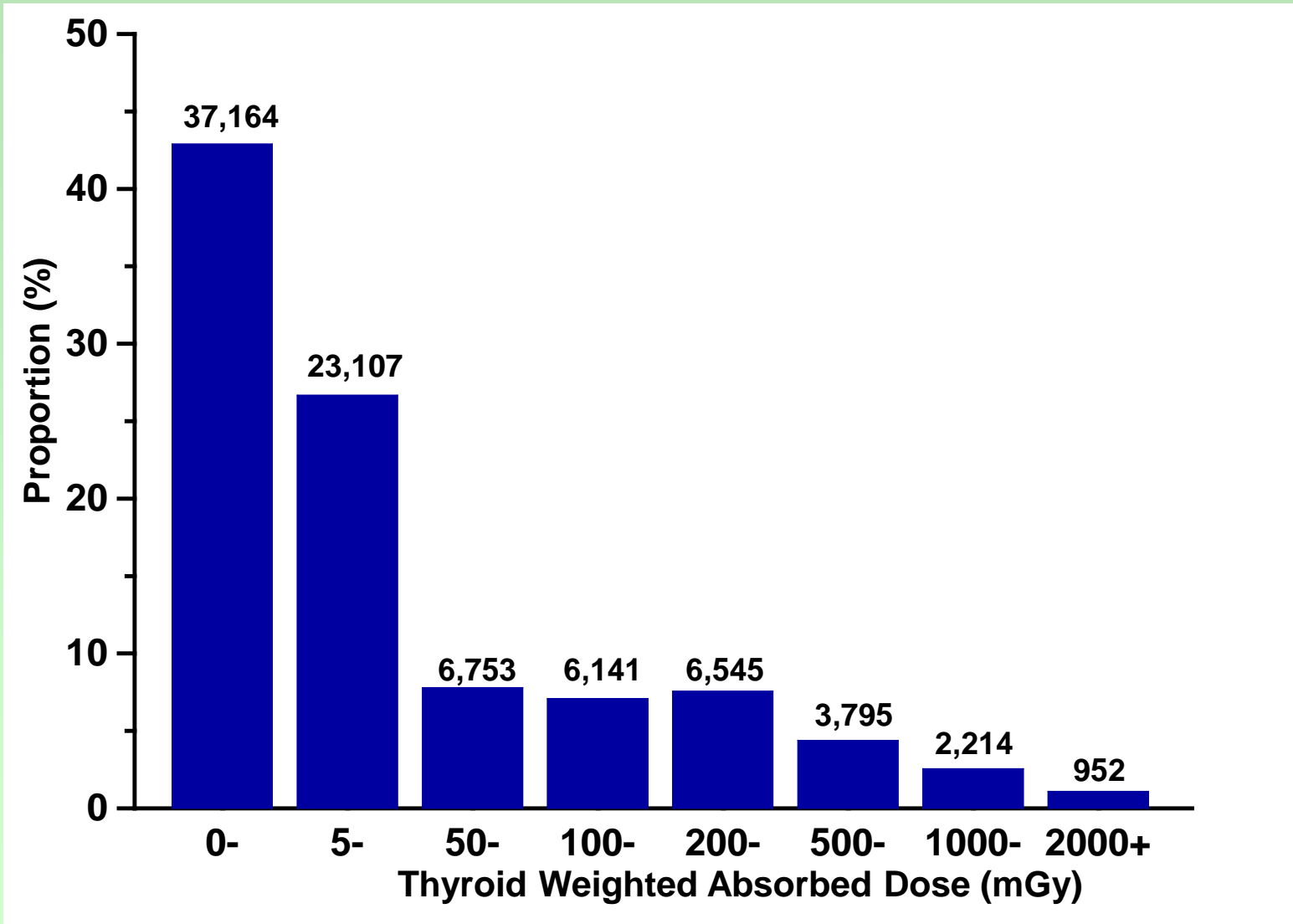
Life Span Study

- ✓ Includes >86,000 survivors of all ages at exposure, with estimated doses and long follow-up for mortality (1950-2008) and cancer incidence (1958-2009)
- ✓ Includes 13,000 exposed before age 5 and 9,500 at ages 5-9, with a wide range of doses (1 mGy to >3 Gy)

Adult Health Study (clinical examinations)

- ✓ Includes >2,600 under 10 years of age, given ultrasound screening

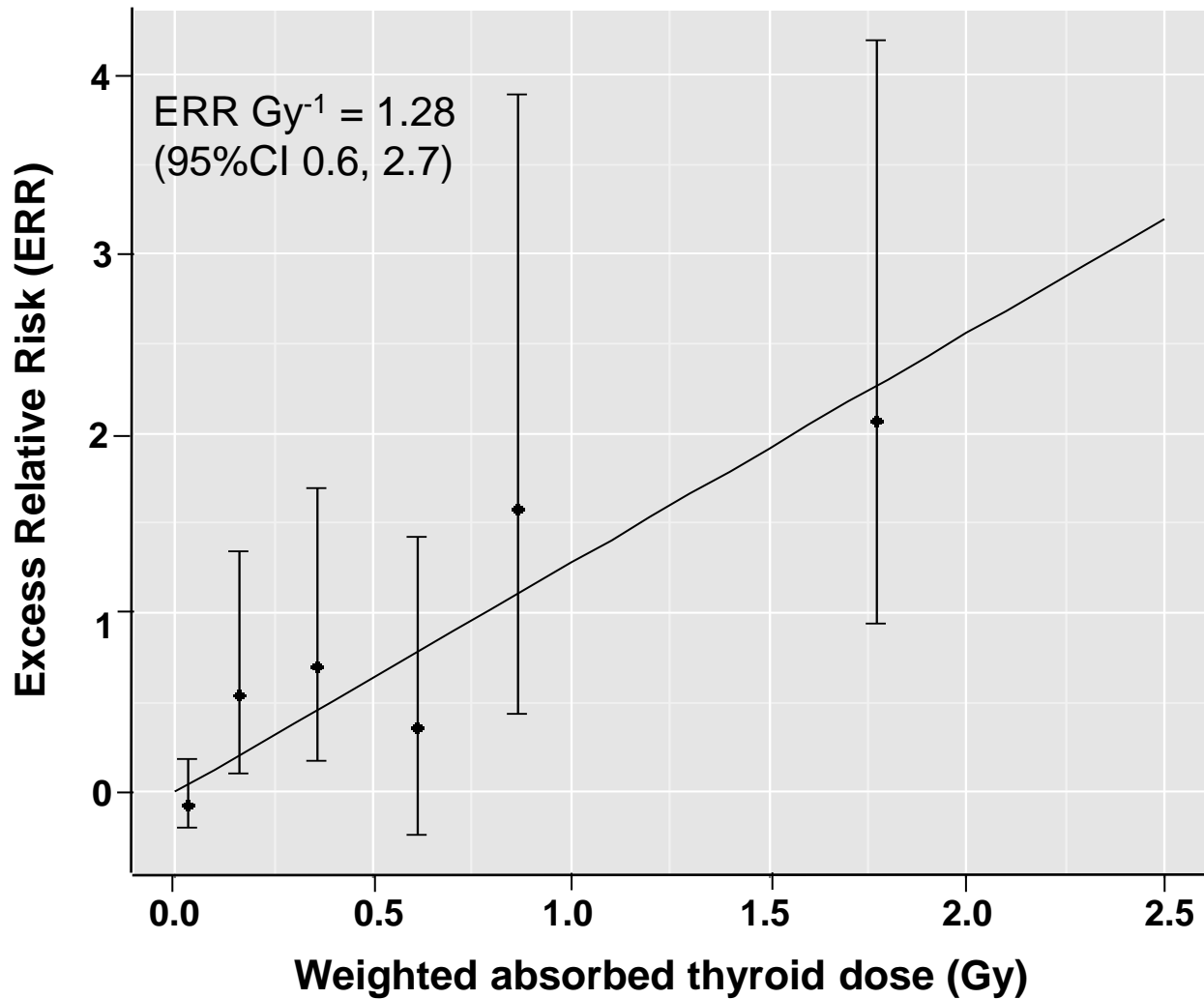
Life Span Study (LSS) Thyroid Dose Distribution



Thyroid dose distribution among those <10 years old at exposure is similar to these.

Thyroid Cancer Risk in the Life Span Study (LSS)

LSS Thyroid Cancer: Dose-response



(Furukawa et al, *Int J Cancer*, 132:1222-26, 2013)

(Modeled for age 10 at exposure and age 60 at risk)

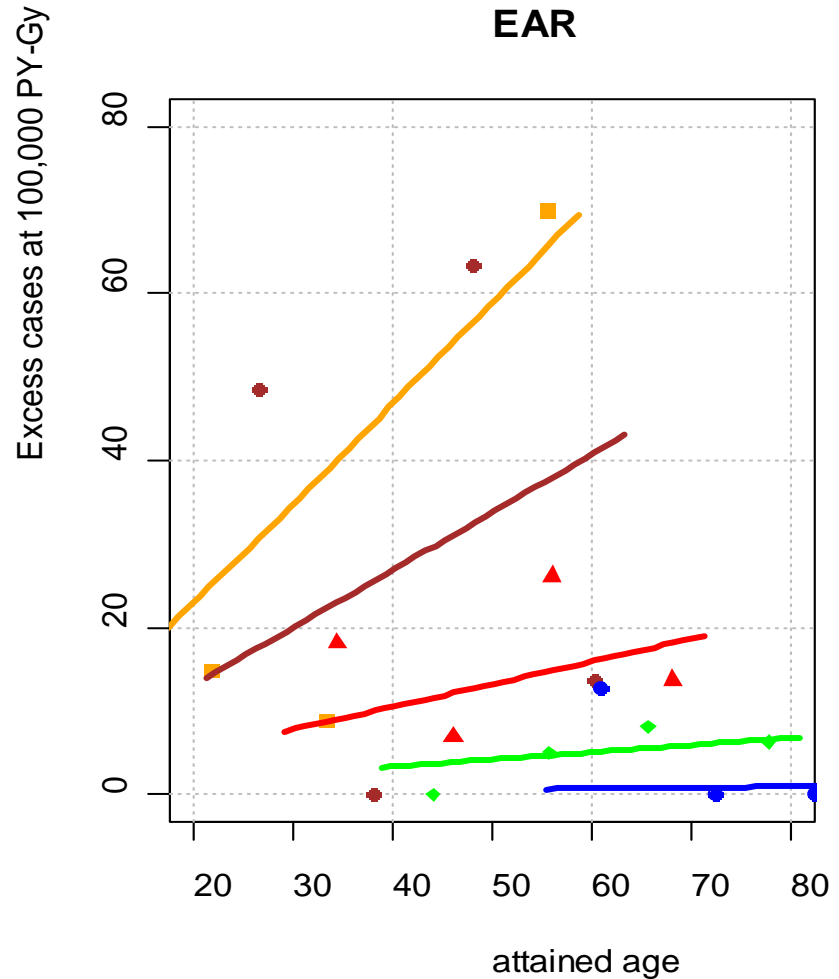
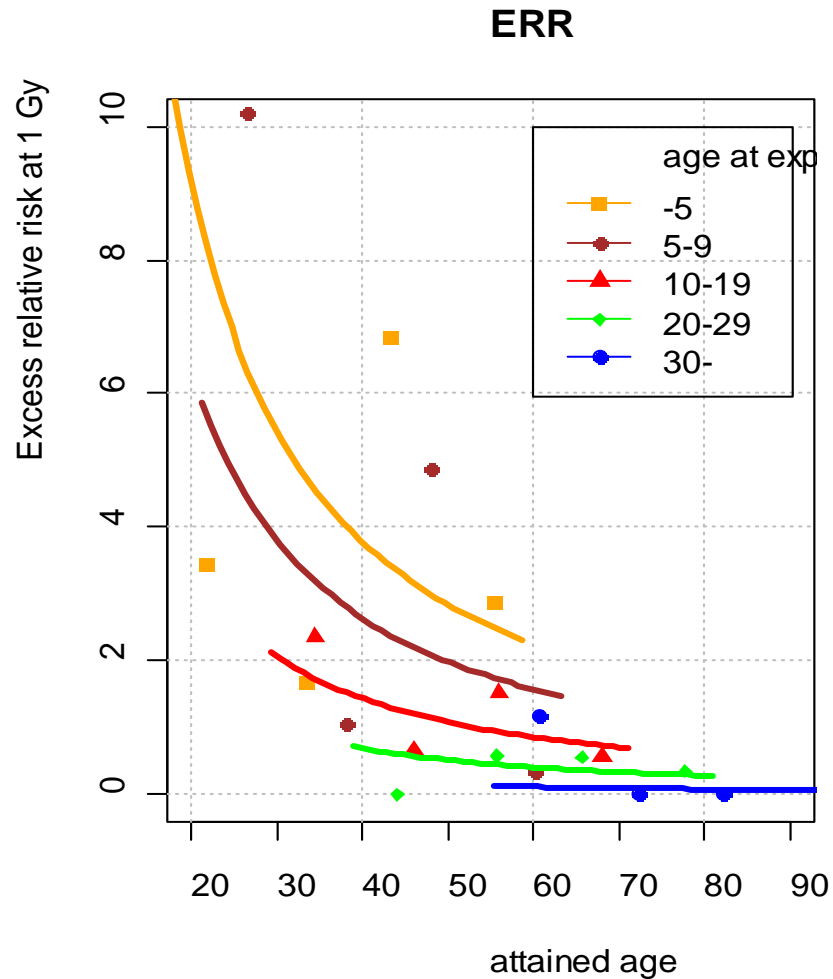
Comparison of LSS Thyroid Cancer Risk with Other Studies of Childhood External Radiation Exposure

| Study | ERR (95% CI) per Gy | EAR (95% CI) per 10 ⁴ PY Gy |
|--|------------------------|---|
| LSS (Furukawa 2013) (est. for IR at age 10) | 1.3 (0.6, 2.7) | 3.0 (1.4, 5.0) |
| Rochester thymus x-ray (age 0; Adams 2010) | 3.2 (1.5, 6.6) | 2.2 (1.4, 3.2) |
| Israel tinea capitis x-ray (ages 0-15; Sadetzki 2006) | 20.2 (12, 32) | 9.9 (5.7, 15) |
| Michael Reese tonsils x-ray (ages 0-15; Ron 1995) | 2.5 (0.6, 26) | 3.0 (0.5, 17) |
| Childhood cancer RT (pooled; Veiga 2012) | 1.3 (0.7, 2.3) | N.A. |

Comparison of LSS Thyroid Cancer Risk with Chernobyl Studies of ^{131}I Exposure

| Study | ERR (95% CI) per Gy | EAR (95% CI) per 10^4 PY Gy |
|---|------------------------|----------------------------------|
| LSS (Furukawa 2013) (est. for IR at age 10) | 1.3 (0.6, 2.7) | 3.0 (1.4, 5.0) |
| Ukraine (screening, exposure ages 0-17; Brenner 2011) | 1.9 (0.4, 6.3) | 2.2 (0.04, 5.8) |
| Belarus (screening, exposure ages 0-18; Zablotska 2011) | 2.2 (0.8, 5.5) | N.A. |
| Ukraine & Belarus (Ecological, ages 0-18; Jacob 2006) | 18.9 (11, 27) | 2.7 (2.2, 3.1) |

Thyroid Cancer Risk by Age at Exposure and Attained Age

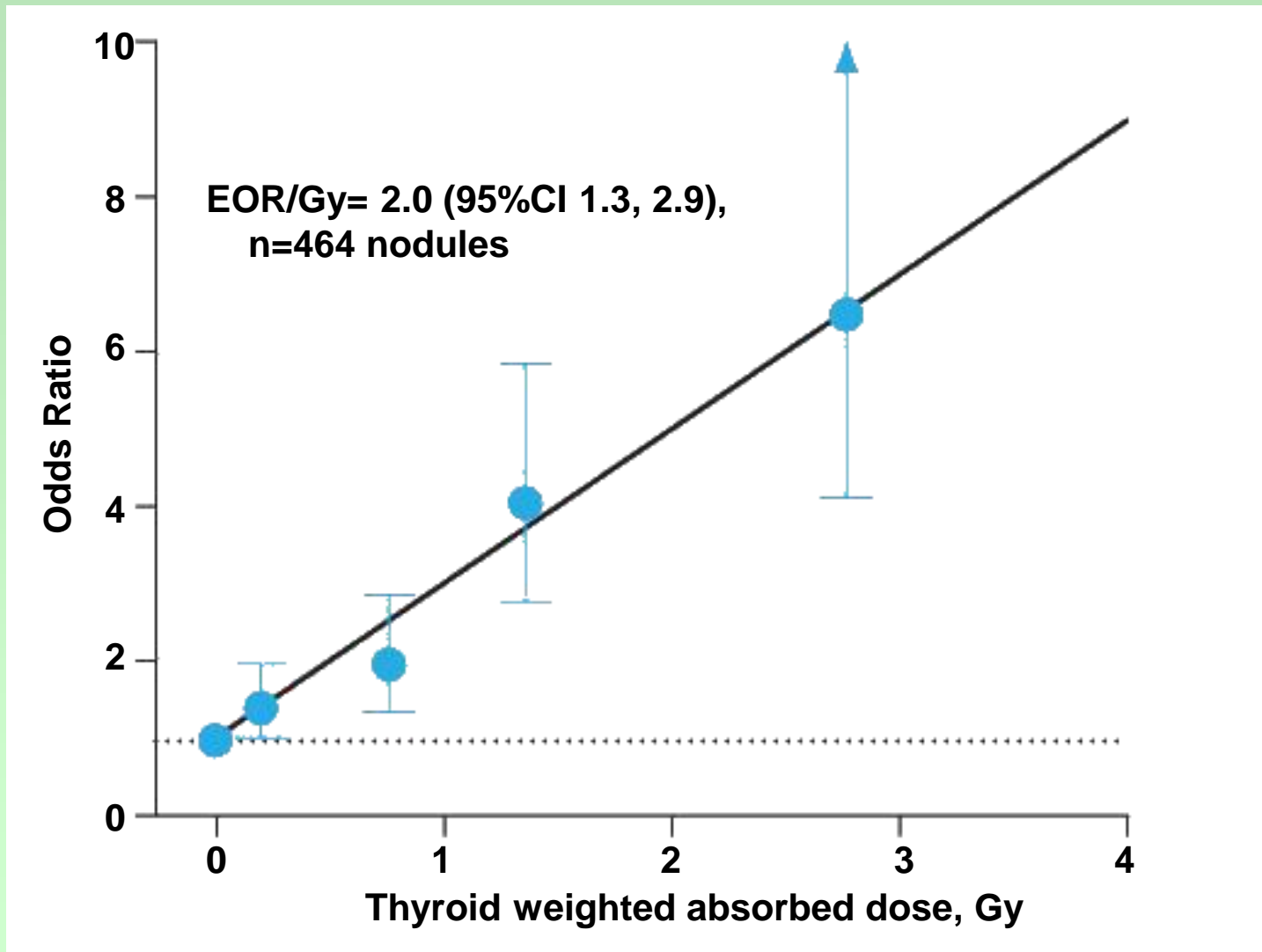


(Adapted from: Furukawa et al, *Int J Cancer*, 132:122-26, 2013)

Thyroid Disease at Clinical Examination in the Adult Health Study (AHS)

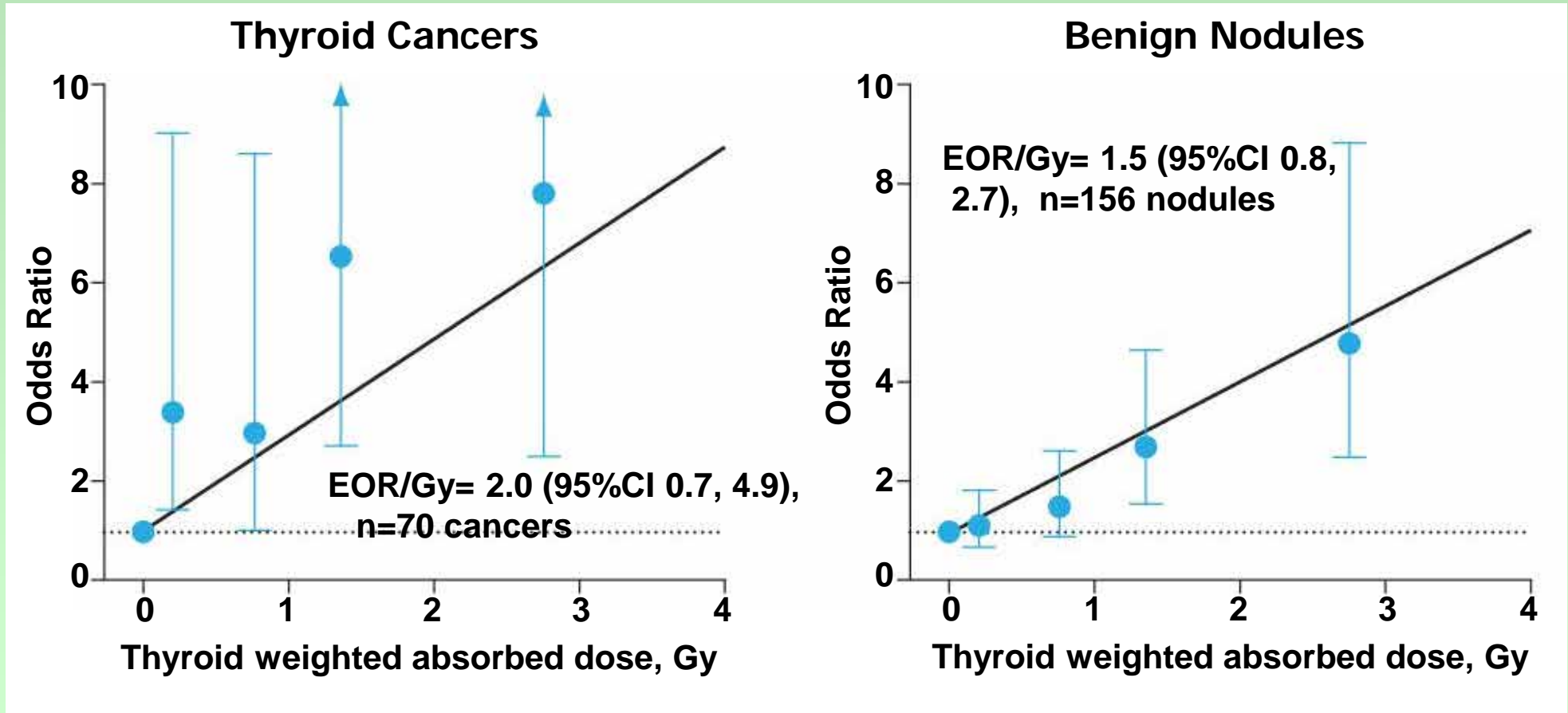
- ✓ **Thyroid examination at the routine AHS health examination**
 - § **Questionnaire: previous thyroid diseases and treatments, family history, seaweed intake**
 - § **Ultrasound examination (detected nodules 5mm)**
 - § **Aspiration biopsy (solid nodules 10mm)**
 - § **Blood tests**
 - **Thyroid function : FT3, FT4, TSH**
 - **Thyroid antibodies**
- ✓ **Tumor information from Tumor Registries**
- ✓ **Medical information (e.g. results of cytology, pathology) from hospitals**

(Imaizumi et al, 2013, unpublished)



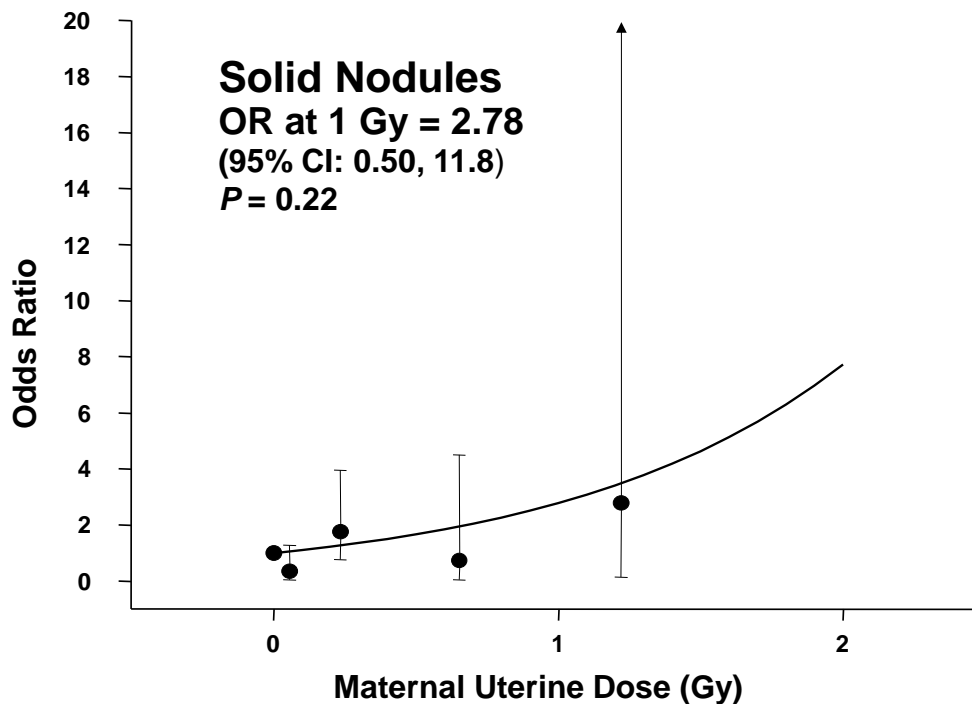
(Imaizumi et al, *JAMA*, 295:1011-22, 2006)

Radiation Dose, Thyroid Cancers and Benign Thyroid Nodules, AHS Screening



(Imaizumi et al, *JAMA*, 295:1011-22, 2006)

In Utero-exposed Clinical Cohort: Radiation Dose-response for Solid Thyroid Nodules



(Imaizumi et al, *J Clin Endocrinol Metab.* 2008;93:1641-8)

Summary of RERF Radiation and Thyroid Effects

- ✓ Over the dose range 0-2 Gy, a **linear** model fits reasonably well.
- ✓ Linear dose-response risk estimate is comparable to nearly all other studies of external irradiation and Chernobyl thyroid studies
- ✓ **For those with <100 mGy:** Increased risk is uncertain, due to little risk and/or limited statistical power.
- ✓ Those exposed at **young ages are clearly at the highest thyroid cancer risk.** Little risk is seen for those exposed as adults.
- ✓ Thyroid cancer risk continues for **>50 years** after exposure.
- ✓ Risk of benign **solid thyroid nodules** is increased by radiation
- ✓ Probably a dose-related risk of thyroid nodules after ***in utero* exposure**, though this study lacked statistical power to fully determine