Partnership between NIOSH and an indium-tin oxide (ITO) company to prevent indium lung disease

R. Reid Harvey

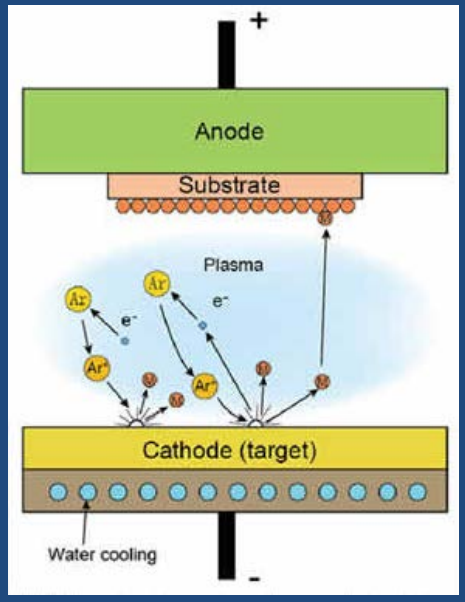
NIOSH Respiratory Health Division

Morgantown, WV

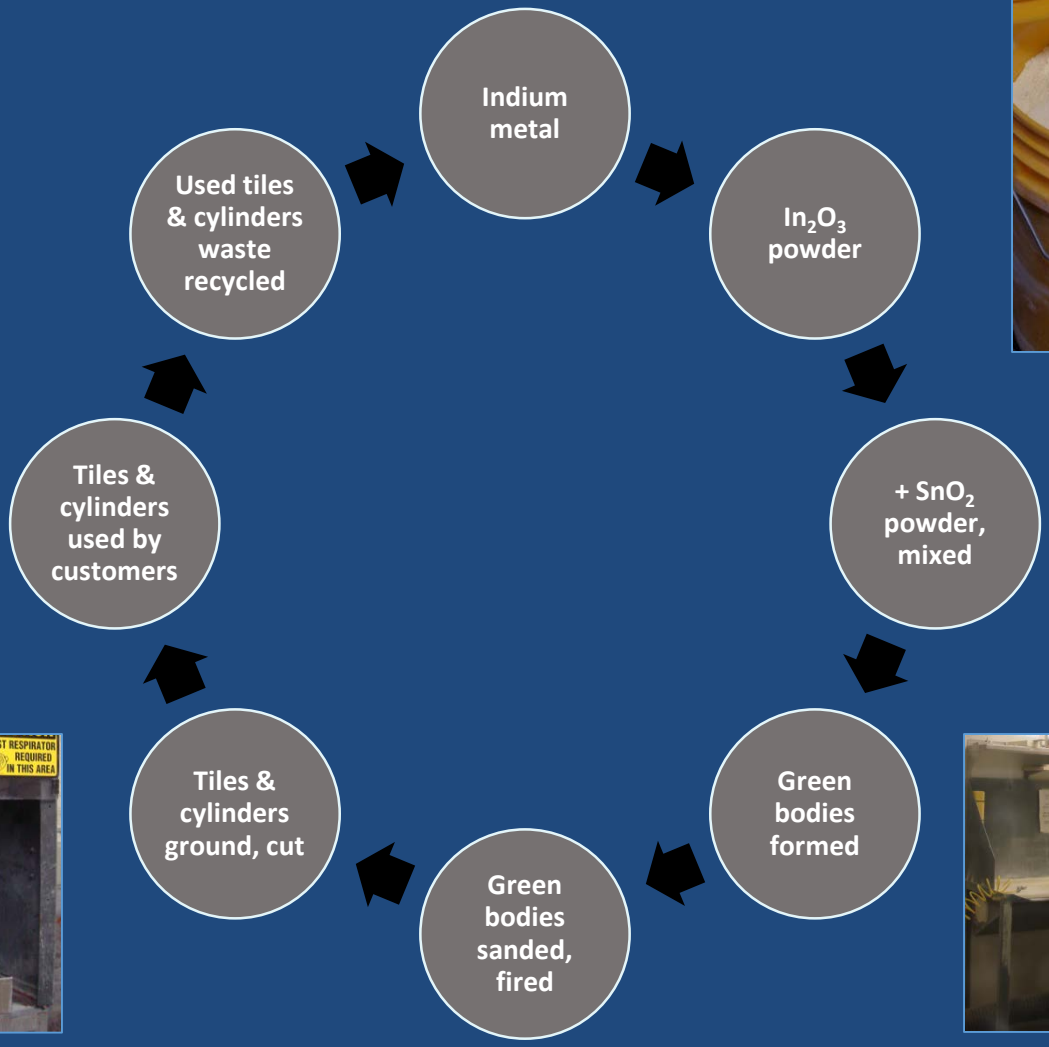
Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

ITO

- Sintered tile: 90% indium oxide, 10% tin oxide
- Transparent conductive oxide
- Many high-tech uses

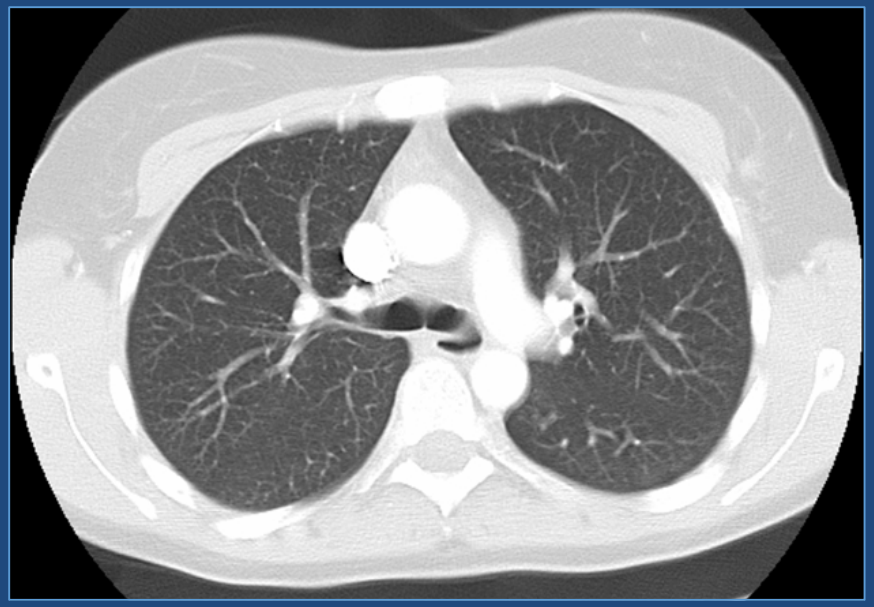


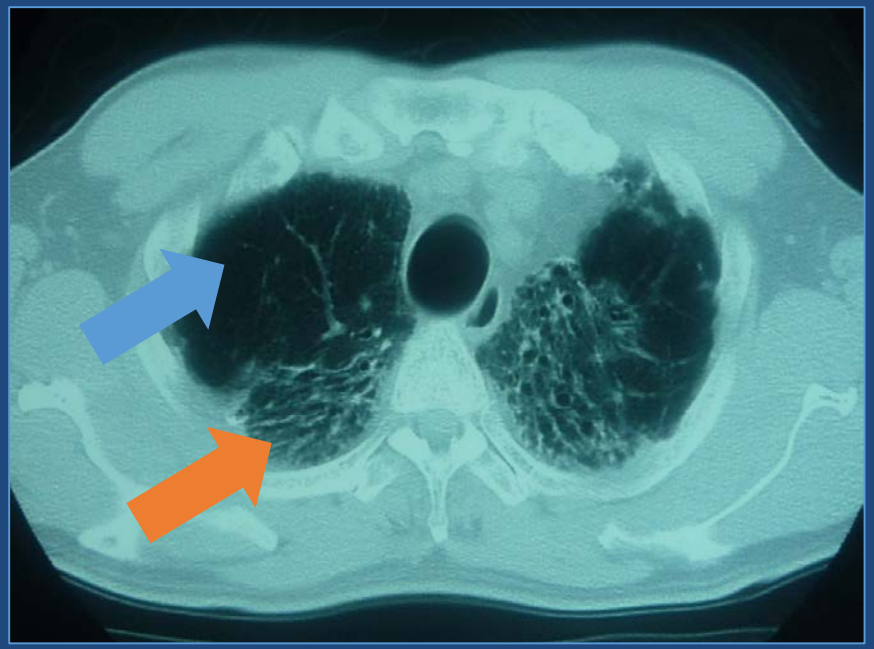
Production ation of ITO



Japanese case reports — 2003–2005

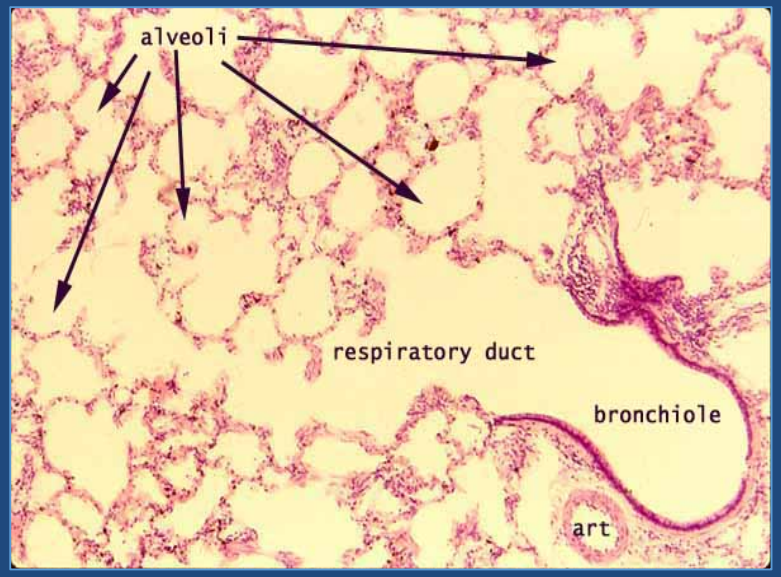
- Workers making ITO targets
- Wet surface grinder for 3 years
  - Interstitial pneumonia
  - Died of collapsed lungs
- Wet surface grinder for 4 years
  - Pulmonary fibrosis
  - Some improvement after transfer

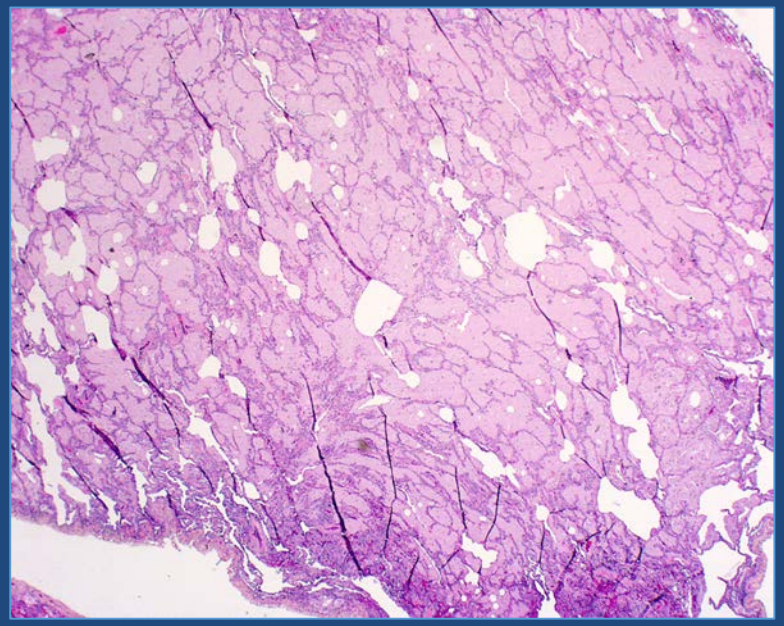




US case reports — 2009–2010

- Pulmonary Alveolar Proteinosis (PAP)
- Reclaim operator
  - Symptoms 9 months after hire in 1999
  - Died of respiratory failure in 2006 despite therapy
- ITO operator
  - Symptoms 6-9 months after hire in 2004
  - Some response to therapy

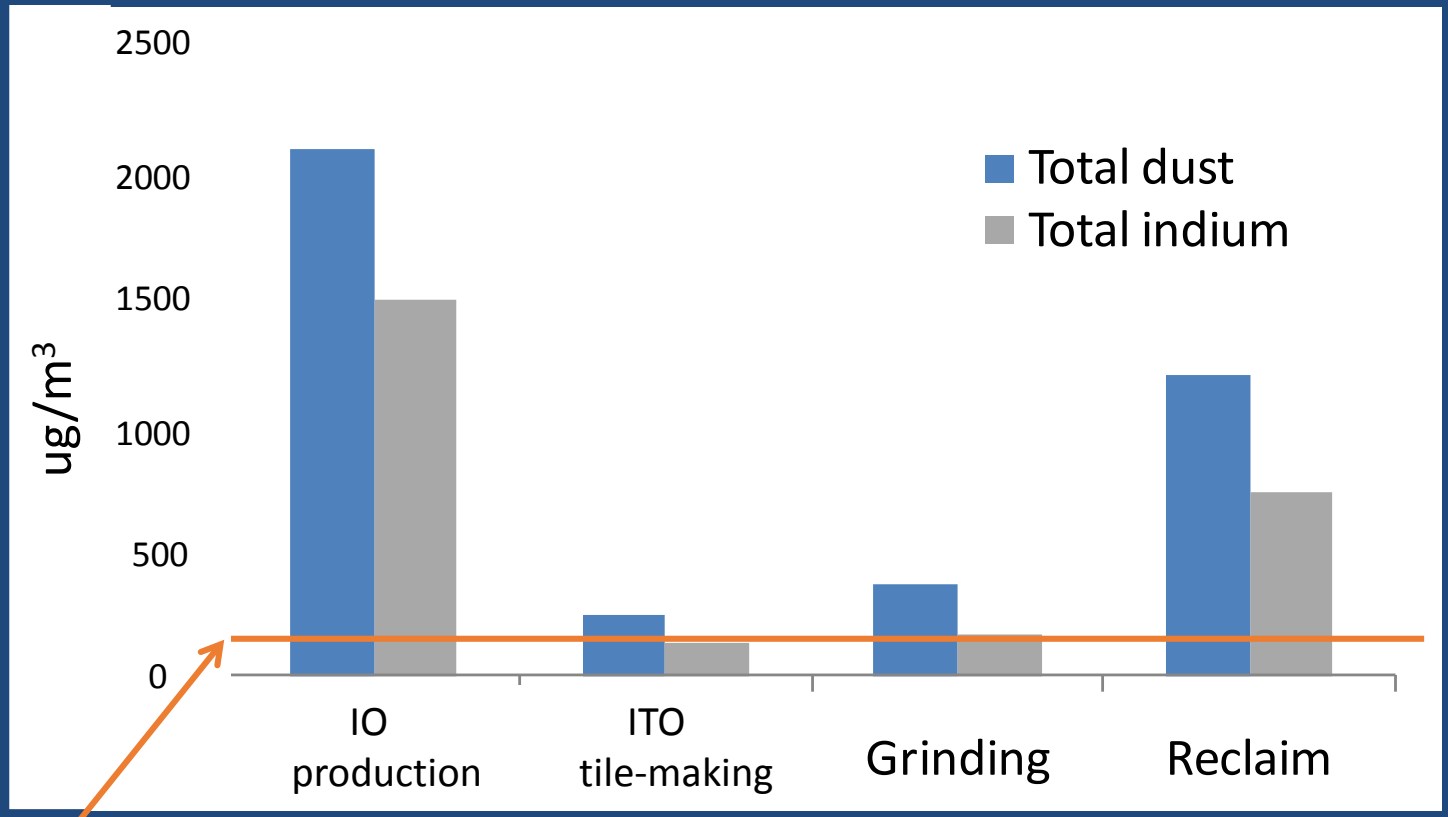




Health Hazard Evaluation (HHE) — 2009

- ITO production company requested HHE
  - Management request
  - Evaluation of workplace changes
    - Industrial hygiene reports
    - Medical surveillance records
    - Personnel records

HHE personal air samples — 2004–2010



NIOSH Recommended Exposure Limit for indium = 100 ug/m^3

HHE medical surveillance — 2002–2010

- 50% had blood indium >5 µg/L after hire
- 31% had spirometric restriction after hire
  - 4 times higher than expected
- 29% had excessive decline in forced expiratory volume in 1 second (FEV_1) during employment
- 14% had abnormal chest radiographs after hire

HHE findings

- Indium air levels exceeded NIOSH REL, highest in IO Production and Reclaim

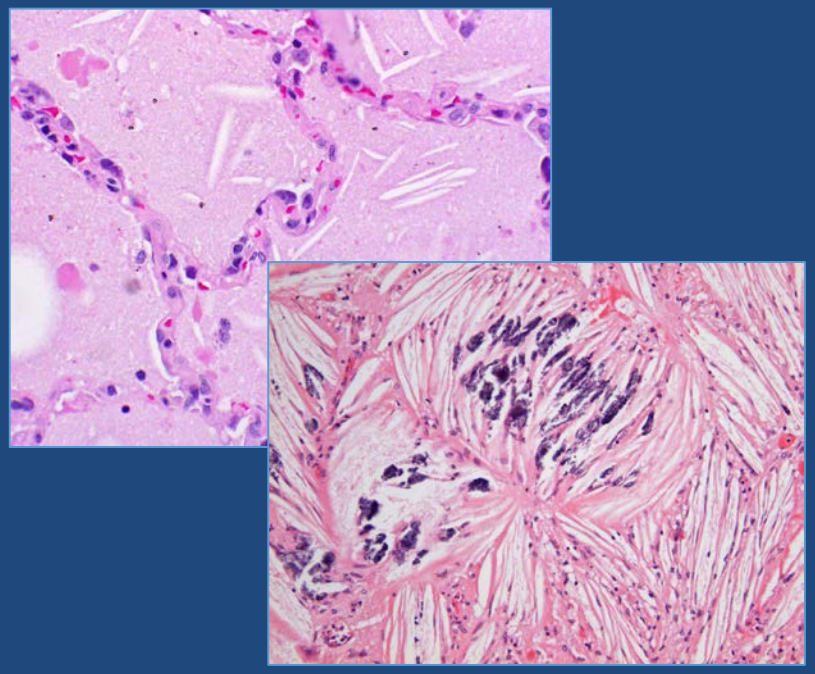
- Excess burden of lung function abnormalities

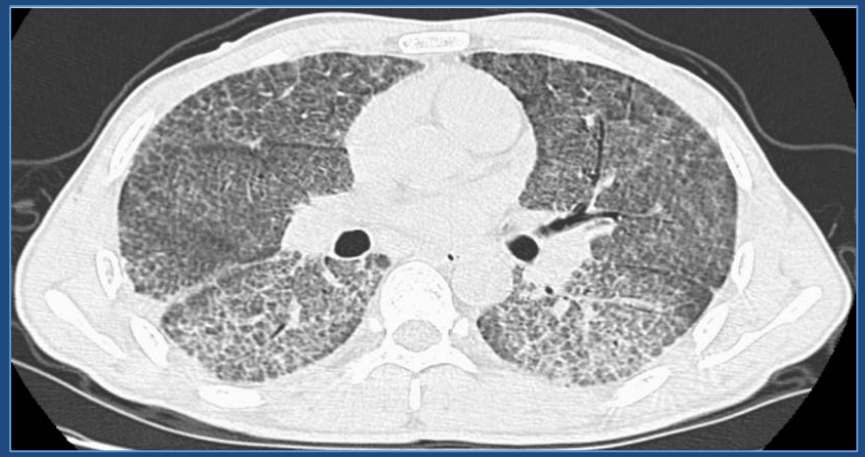
International workshop — 2010

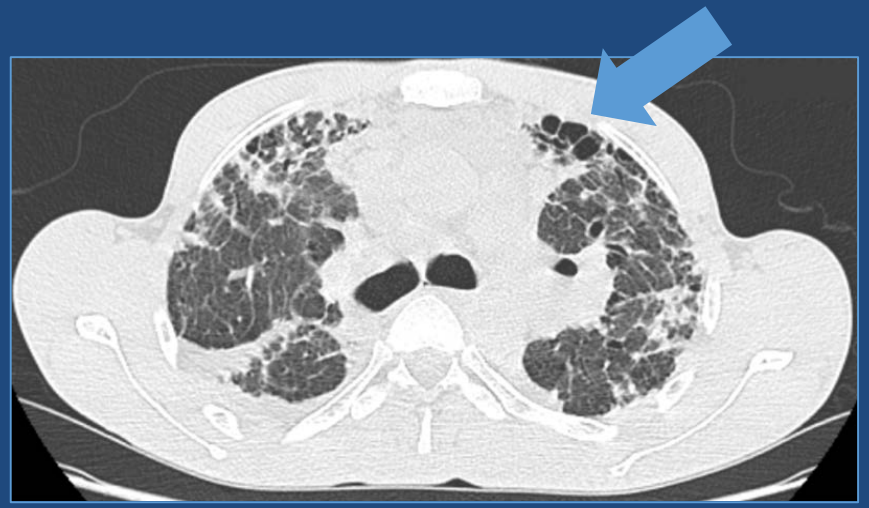
- Same or different diseases in Japan and United States?
- Physicians, epidemiologists, industrial hygienists
- United States, Japan, China, Korea represented
- Reviewed clinical and epidemiologic data from reported cases and workplaces
  - 10 cases, 1–12 years exposure at ITO, In_2O_3 or LCD facilities
  - 8 cases worsened (2 died), mean blood indium 113 µg/L; 2 cases stabilized or improved, mean blood indium 40 µg/L

International workshop — 2010

- Shared histopathological features
  - Alveolar filling (n=9)
  - Cholesterol clefts, granulomas (n=10)
  - Fibrosis (n=9)
- Radiographic progression
  - From PAP to fibrosis, emphysema
- Appears to be one disease that progresses over time







NORA project — 2012–2015

- What is the respiratory health status of the workforce?
- What is the level of exposure to indium compounds?
  - Plasma indium (µg/L)
  - Respirable indium (µg/m3)
- Is there a relationship between these exposure metrics?
- Are there relationships between exposure metrics and health?
  - If so, do these progress overtime?
- What are the toxicity profiles of ITO and other indium compounds?

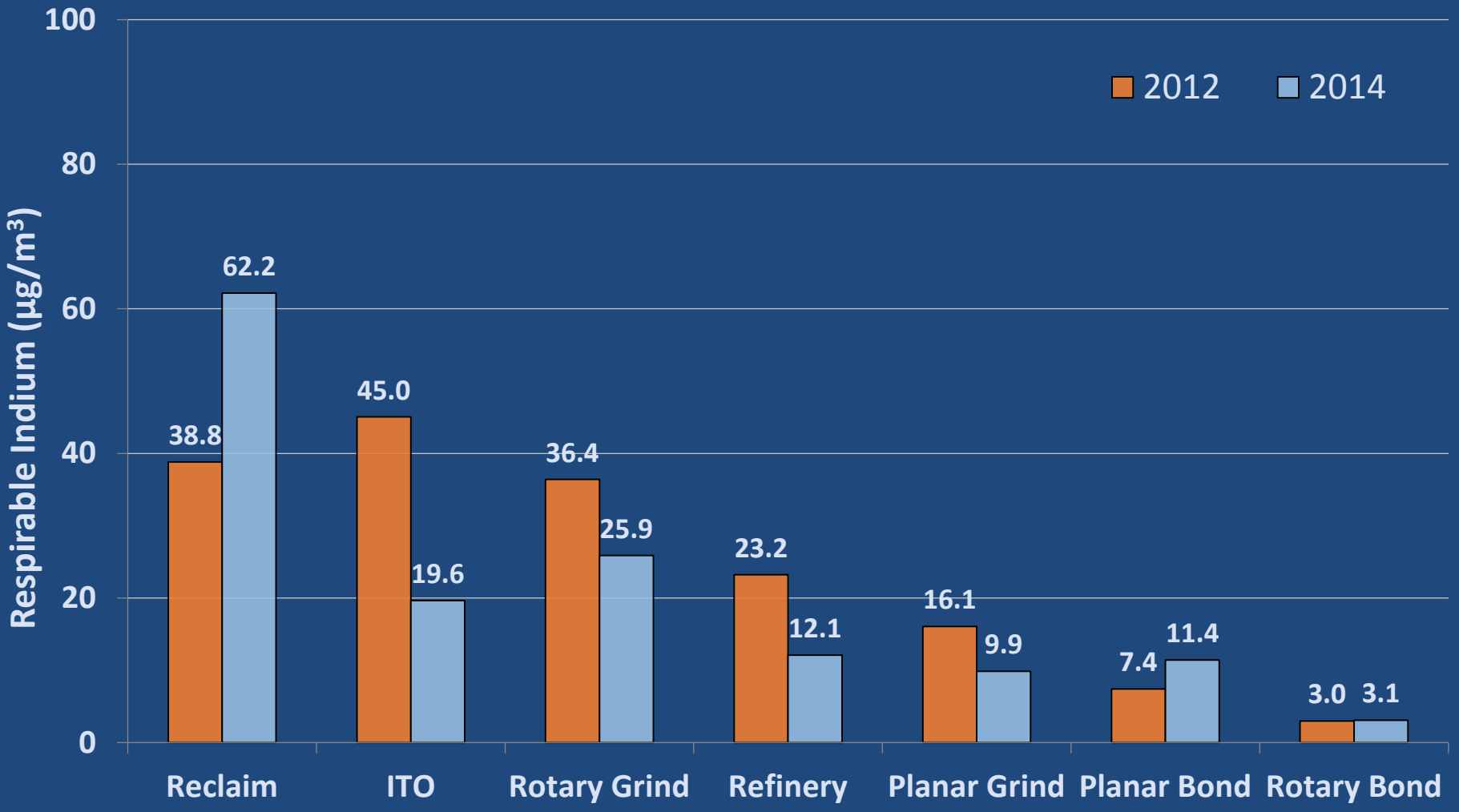
Industrial hygiene evaluations in 2012 & 2014

- Personal sampling
  - For time-integrated respirable indium, dust
  - For real-time respirable dust
- Area size-selective sampling
  - For indium, dust
- Observational data on tasks, tools, controls and materials used (real-time & hourly intervals)

Picture from BGI.com

Picture from SKCinc.com

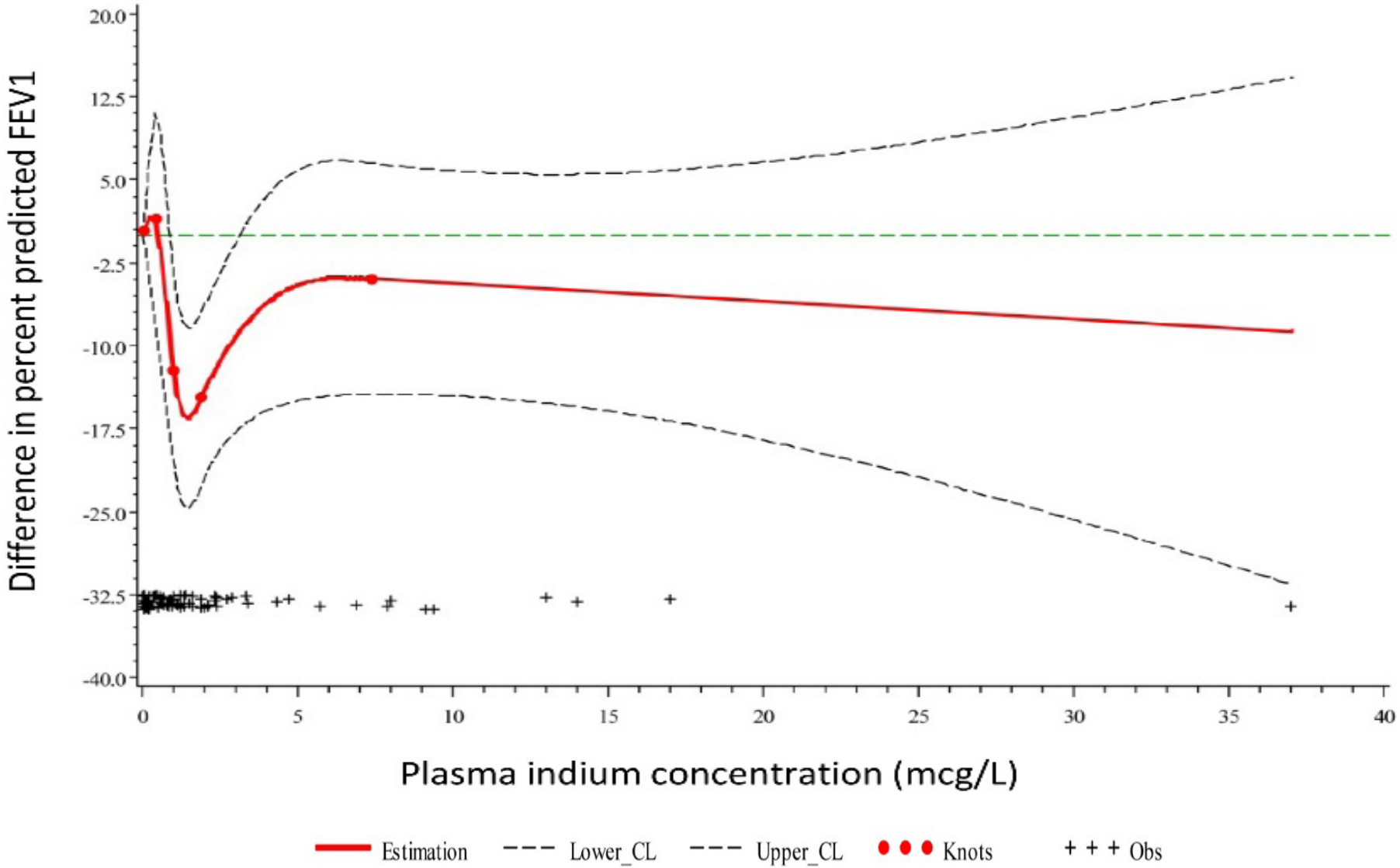
Personal samples respirable indium: production, geometric mean



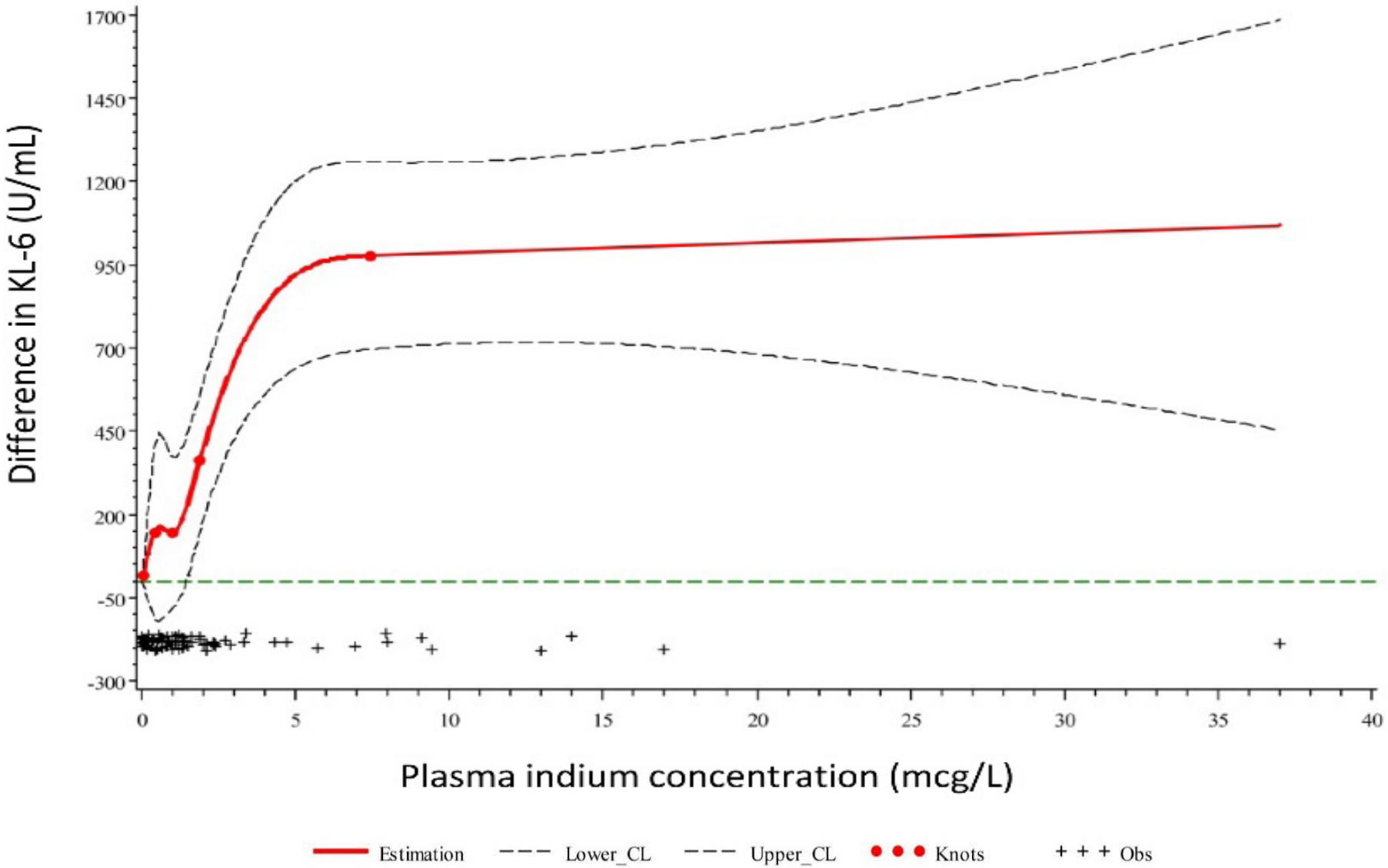
Medical evaluations in 2012 & 2014

- All current workers eligible to participate at each evaluation
- Interviewer-administered questionnaire
  - Respiratory symptoms & diagnoses
  - Work history including job & department information
- Spirometry and diffusing capacity
- High-resolution computed tomography (HRCT) scan of chest
- Serum biomarkers of interstitial lung disease, namely Krebs von den Lungen (KL)-6 and surfactant protein (SP)-D
- Plasma indium concentration

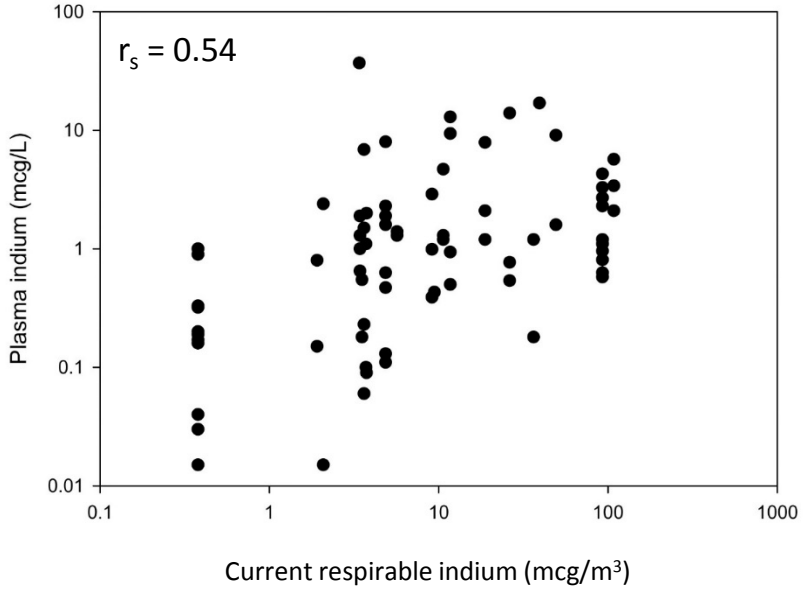
%FEV_1 and plasma indium

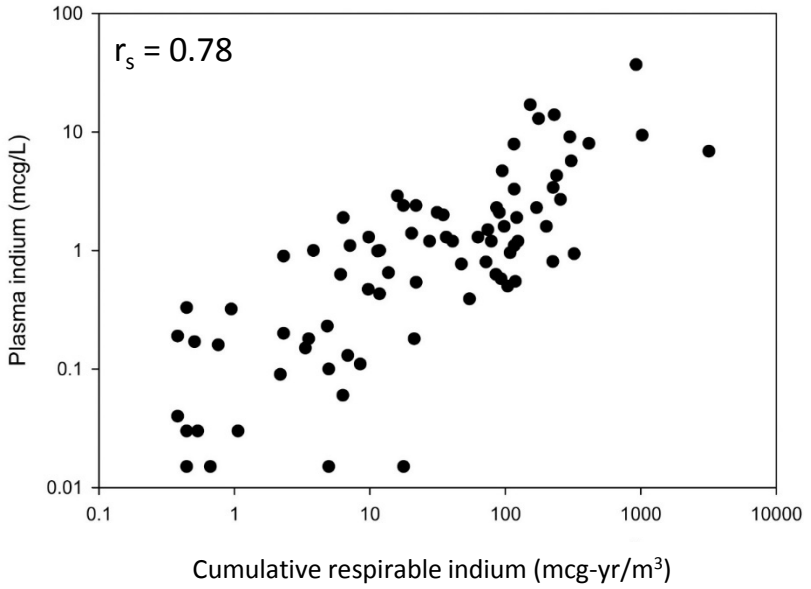


KL-6 and plasma indium

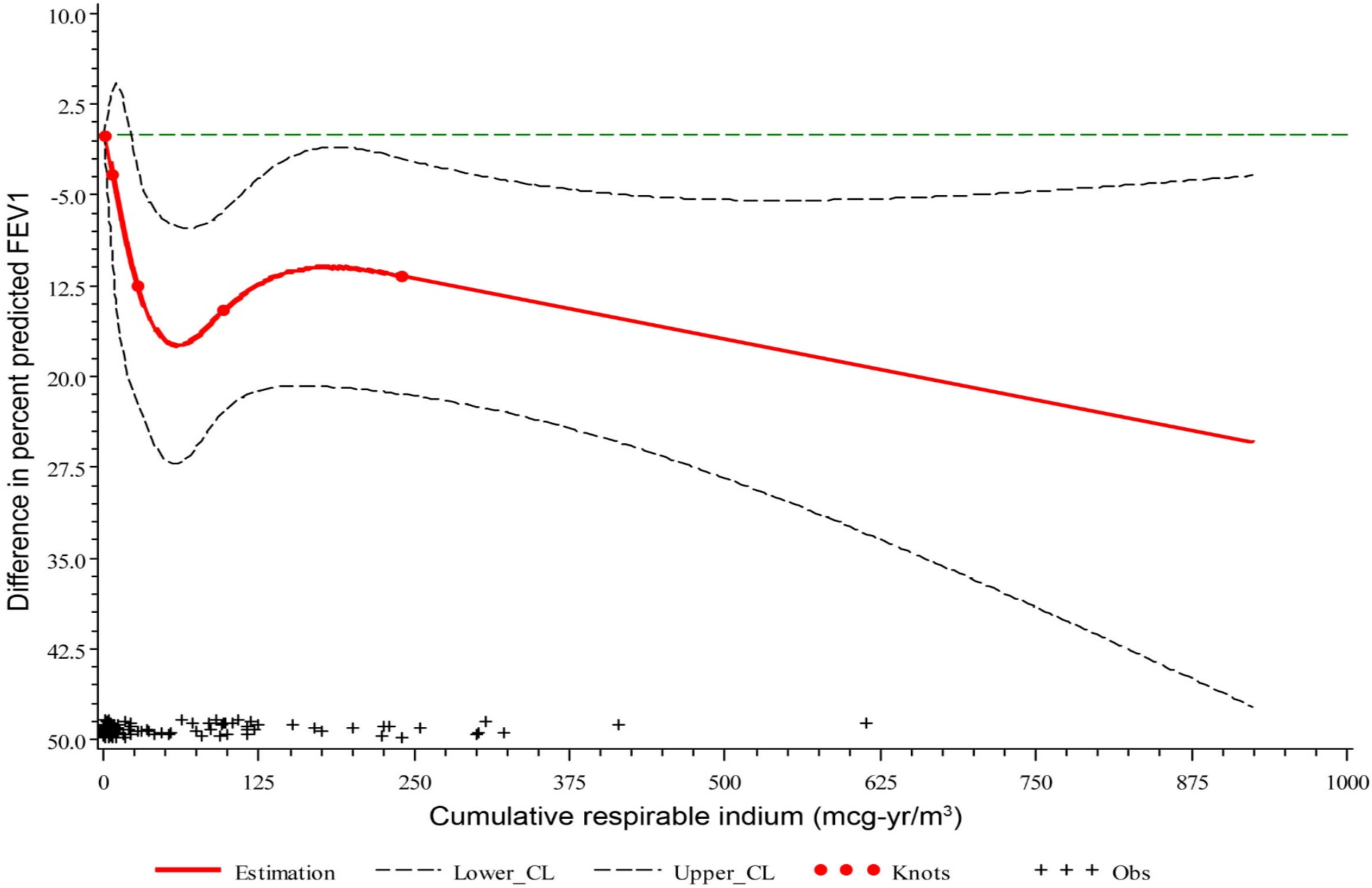


Plasma indium and respirable indium

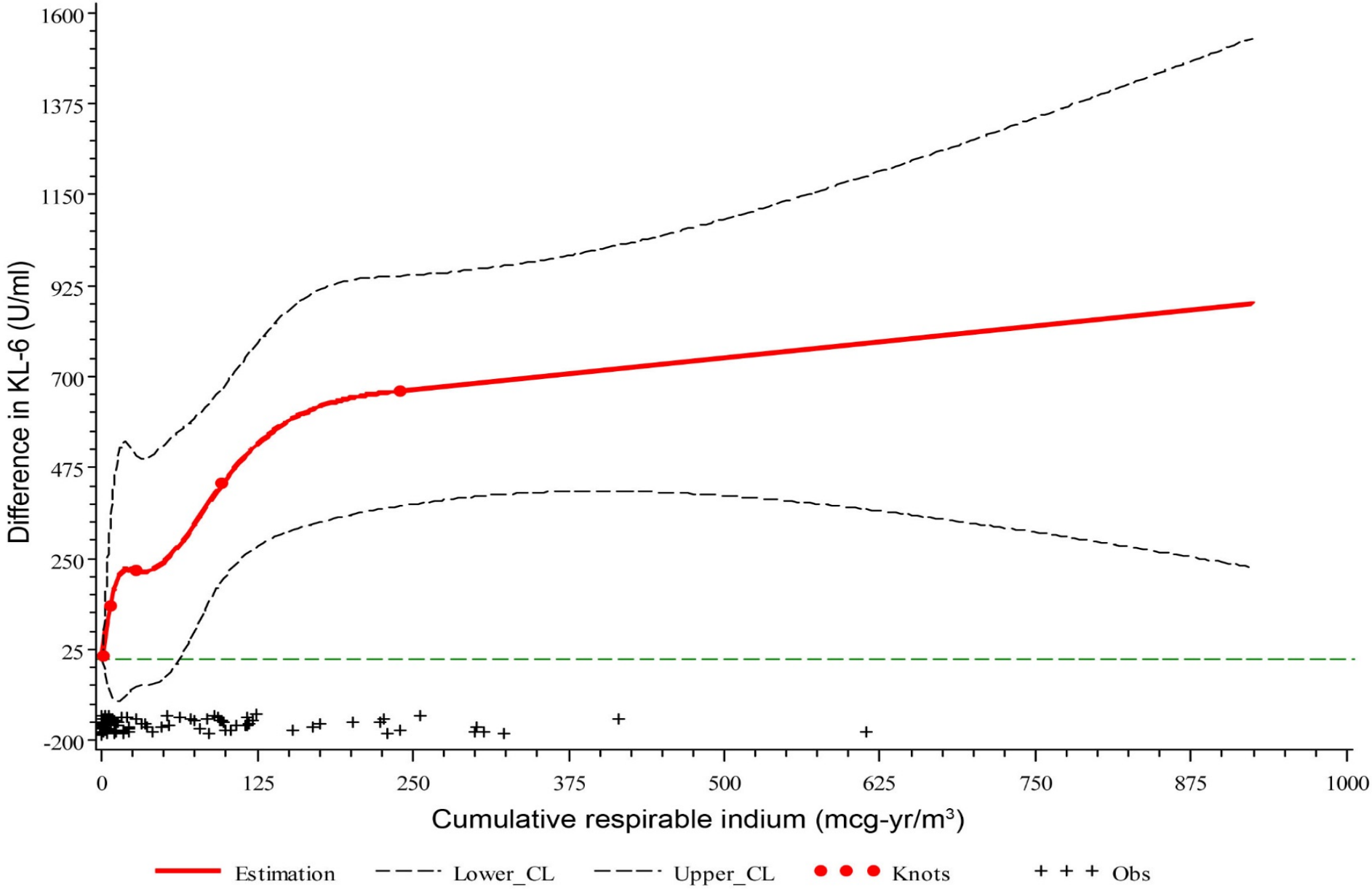




%FEV_1 and cumulative respirable indium



KL-6 and cumulative respirable indium

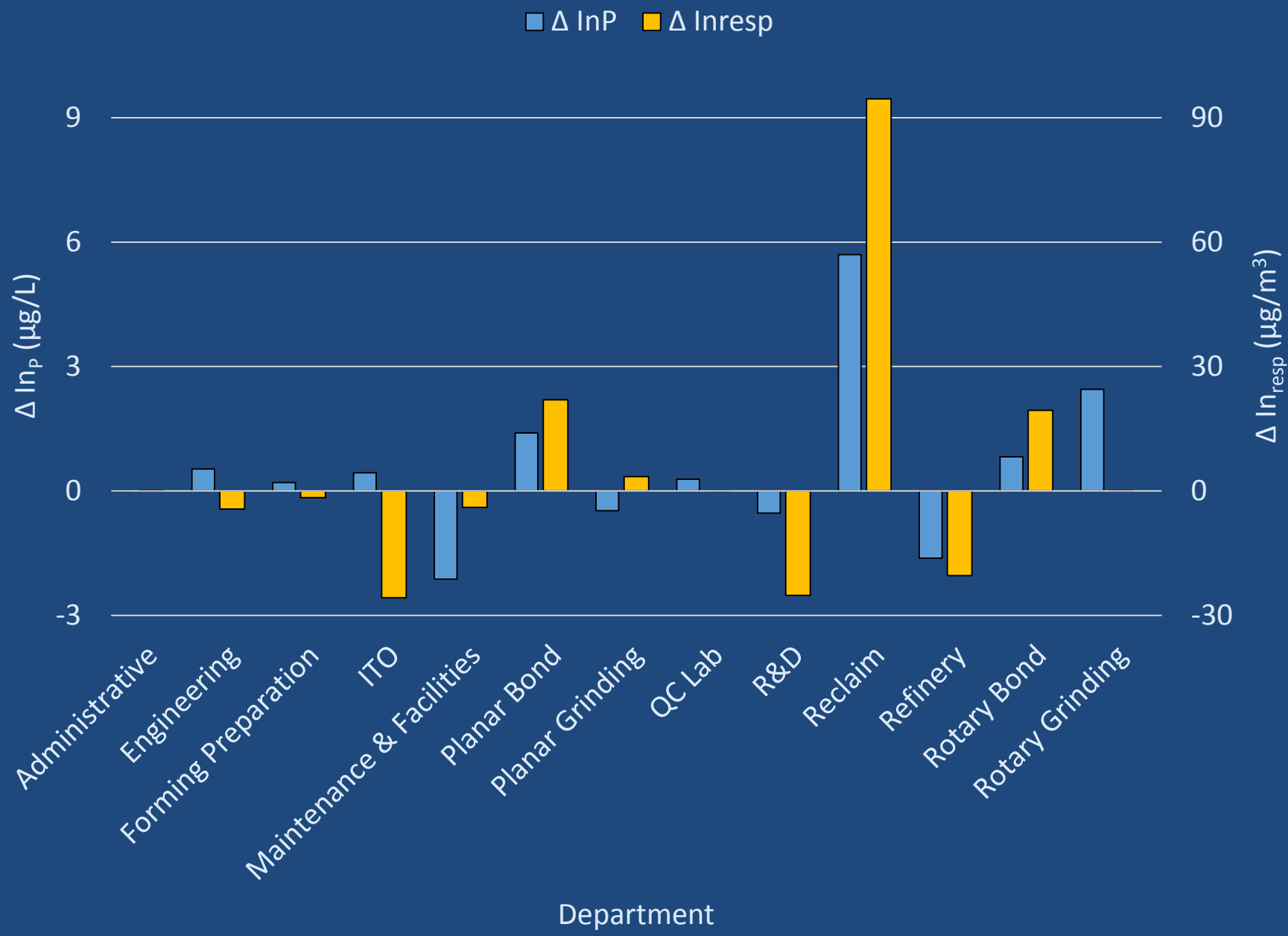


Longitudinal evaluation of respiratory health and exposure indices

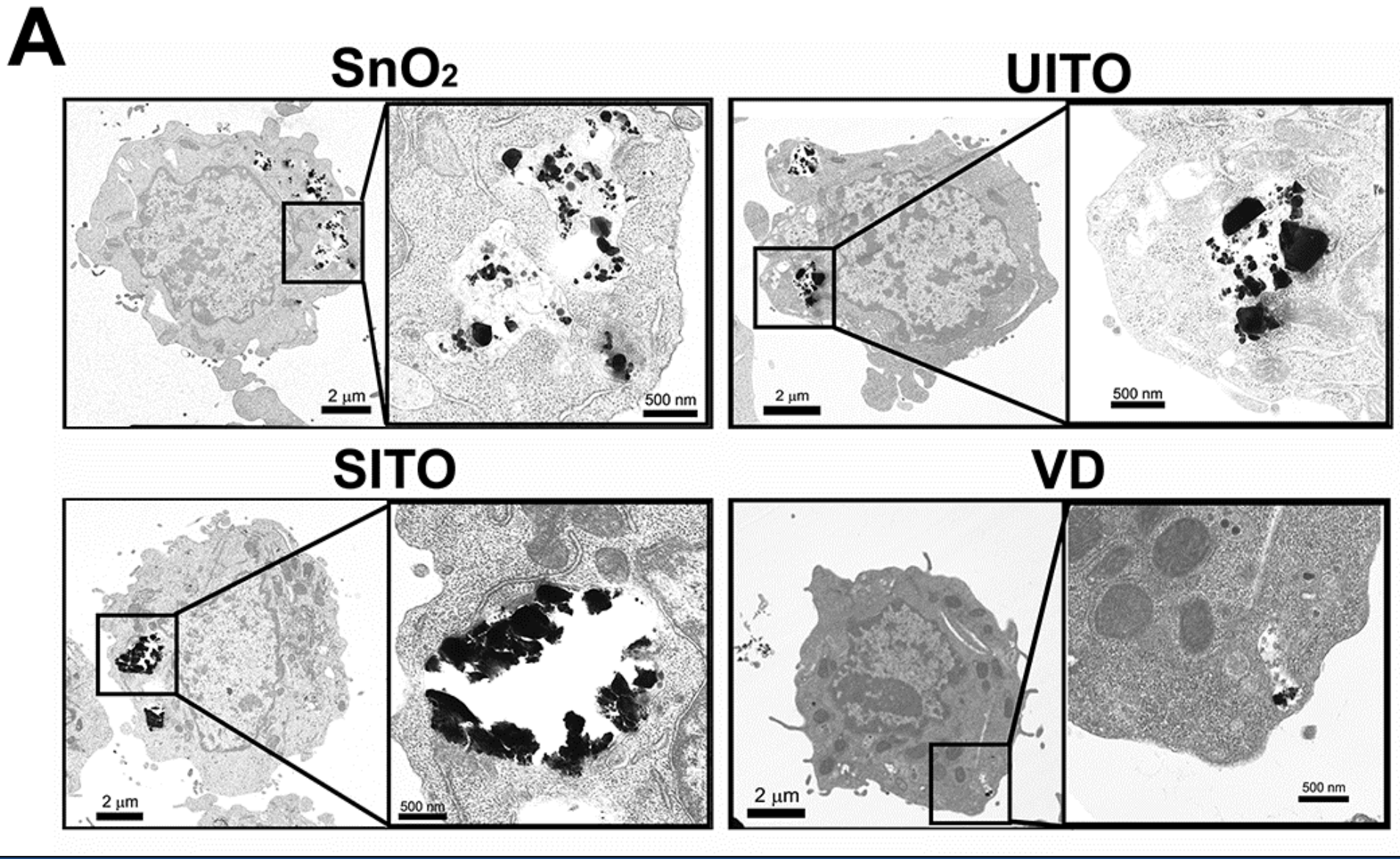
2014 Health Outcome	ΔIn_P ≥0.2 µg/L	Log interval In_{resp}
	OR (95% CI)	OR (95% CI)
New chest symptom	**4.2 (1.2; 17)**	**1.6 (1.0; 2.5)**
KL-6 > 500 U/mL	3.9 (0.7; 29)	**2.6 (1.4; 6.0)**
	β coefficient	β coefficient
% predicted DLCO	**-4.5 (-8.2; -0.1)**	-1.3 (-3.8; 1.2)
% predicted V_A	**-3.4 (-6.3; -0.4)**	-0.3 (-2.3; 1.8)
% predicted FEV_1	-2.7 (-6.6; 1.2)	-1.9 (-4.4; 0.7)
% predicted FVC	-3.1 (-6.3; 0.2)	-0.9 (-3.1; 1.3)
FEV_1/FVC ratio	0.1 (-1.9; 2.0)	-0.3 (-1.6; 1.0)
KL-6 (U/mL)	83 (-40; 205)	65 (-18; 148)
SP-D (ng/mL)	18 (-22; 57)	-2.7 (-30; 24)

*Adjusted for age, smoking status and 2012 plasma indium

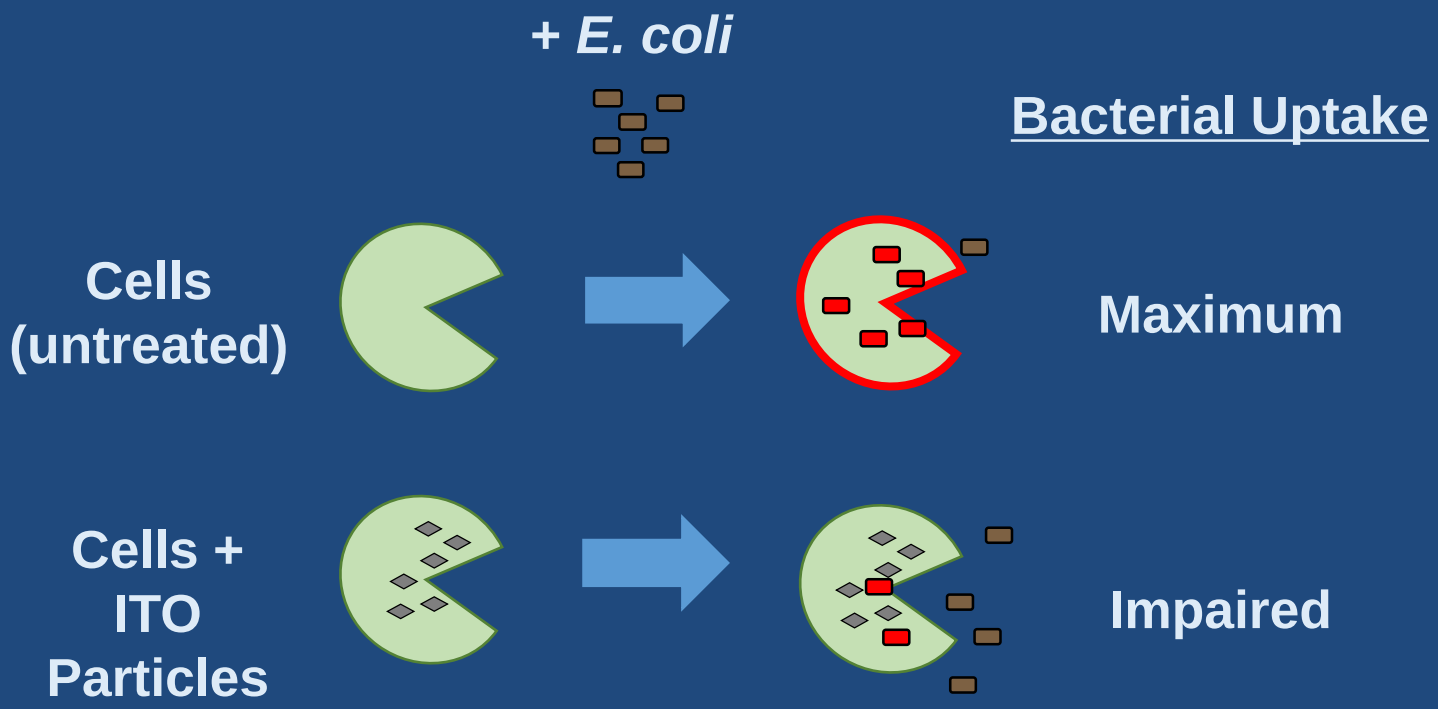
2012–2014 change in plasma and respirable indium



Cellular uptake of indium-containing particles



Macrophage Dysfunction



Impact to date

- HHE findings can influence workplace improvements in a timely fashion, and stimulate further multidisciplinary research
- ITO production company utilized NIOSH findings to advance efforts to reduce worker exposure and prevent clinical indium lung disease
- Company recently finalized strict internal standards to further protect workers and incorporating NIOSH findings into development of a new facility in China
- Substantial contribution to knowledge of indium lung disease, including establishing risk of the emerging occupational respiratory disease

Works in progress — 2017

- Dose modeling to estimate alveolar dose resulting from different forms and patterns of indium exposure

- Cluster analyses to determine if grouped health outcomes are associated with exposure

- Exposure analyses
  - Compare respirable and inhalable indium and dust exposure taking into account particle size distribution
  - Investigate the determinants of full-shift indium exposure such as tasks, materials used and controls
  - Model the determinants of real-time dust exposure and evaluate its use to identify peaks and high exposure tasks

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ITO Production and Reclamation Company

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

Implementation Science: What is it and what do we know about successfully translating OSH solutions into worker practice?

Paul Schulte, PhD: NIOSH
Jennifer Lincoln, PhD, CSP: NIOSH
Eileen Betit, BA: The Center for Construction Research
Julie Sorensen, PhD: The Northeast Center for OSH
Anna Gadomski, MD, MPH: The Northeast Center for OSH

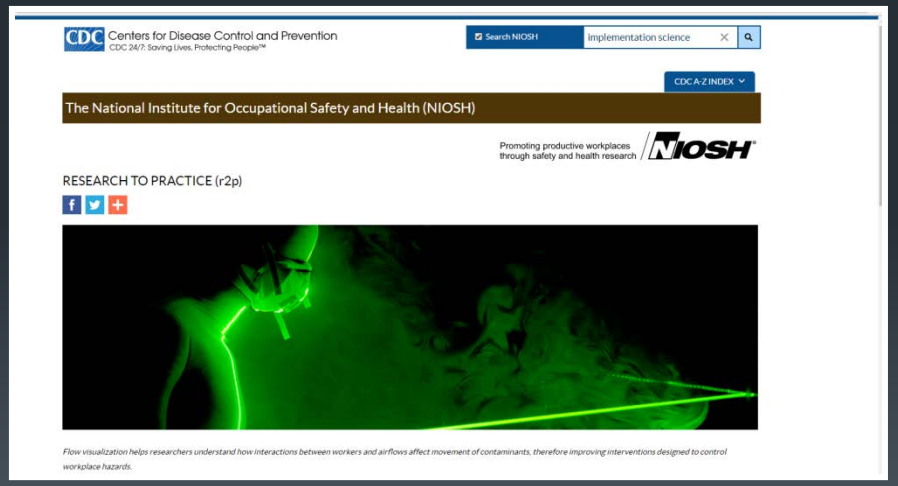
Presentational Overview

1. Define translational science and phases (Dr. Schulte)
2. Fishing safety translational success story (Dr. Lincoln)
3. Construction translational success story (Ms.. Betit)
4. Farming translational success story (Dr. Sorensen)
5. Translating evidence-based research (Dr. Gadomski)
6. Summary – Demonstrating impact in OSH research

Translation Research in OSH

Paul Schulte, Ph.D. and Tom Cunningham, Ph.D.

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



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The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy

NIOSH

NAS Report 2009

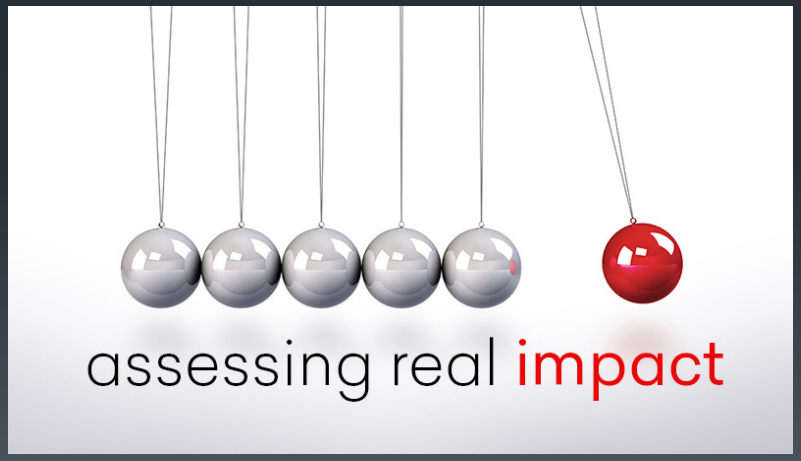
- "Much remains to be learned about how to improve the likelihood that research translation efforts will positively impact worksites."

- "Continued contribution by NIOSH to research on improving the effectiveness of translation efforts will ensure consideration of the dynamics that characterize occupational safety and health."

NAS 2009

What is Translation Research?

- Study of the processes, drivers and barriers that affect the relationship between research outputs and downstream outcomes.



Translation Research is Not:

- r2p
- Translation

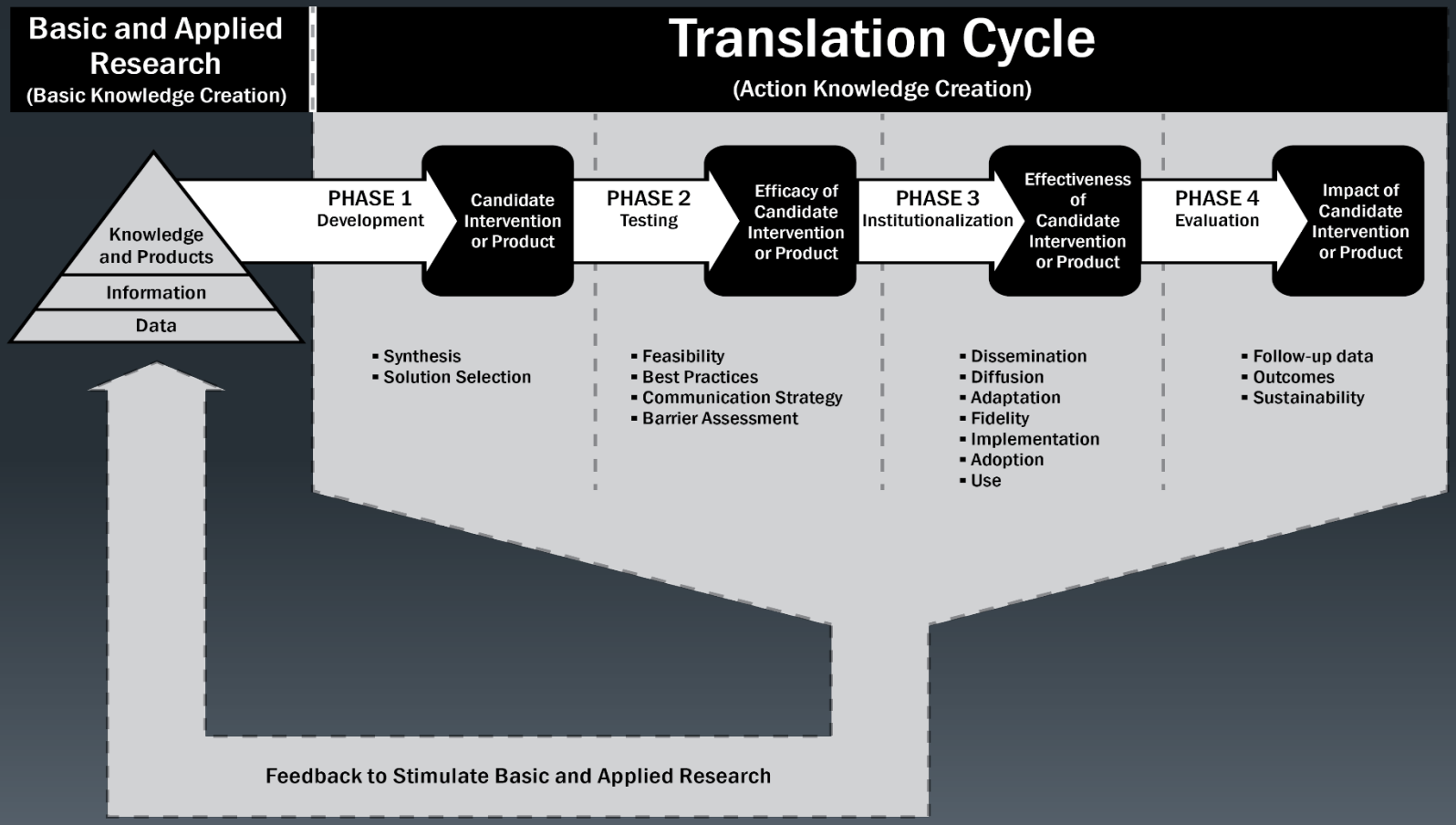
Rather it is the study of those activities

Basis of OSH Translation Research

- NIH model (2003):
  - —“bench-to-bedside”
  - —4 phases:T1—T4
  - —Characterized by moving findings to a larger scale
- Knowledge to Action (Graham et al 2006); Knowledge Transfer and Exchange (Lavis et al 2003)
- Determining how best to make those transitions

Overview of OSH Translation Research

Figure 1: Overview of Translation Research for OSH



The 4 Phases of Translation Research

Phase	Description	Role of OSH Research
1 Development	Generating solutions and limited testing to select best candidates	Research and development; discovery studies
2 Testing	Observational and experimental studies	Efficacy and internal validity
3 Institutionalization	Assess facilitators and barriers to widespread implementation	External validity; Adoption and implementation, sustainability
4 Evaluation	Population level outcomes	Impact on health, safety, economics, and well-being

Translational Success Stories – Commercial Fishing

Jennifer Lincoln, PhD

30 years of NIOSH Research

Commercial Fishing Vessel Industry Safety Act of 1988 (CFIVSA):

- Developed to reduce high fatality rate
- Implemented 1990-1995
- No licensing or vessel requirements
- Focus placed on secondary prevention
  - -Surviving a vessel disaster
  - -Survival gear

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Articles Identified as T4 Research

Series of articles studying CFIVSA

- **Conway G, Lincoln J, Jorgensen S, Klatt M, Manwaring, J. (1998). Preventing deaths in Alaska's commercial fishing industry. *Circumpolar Health* 96:503-509.**
- **Lincoln J and Conway G. (1999) Preventing commercial fishing deaths in Alaska. *Occp Environ Med* 56:691-695.**
- **Lincoln J, Husberg B, Conway G. (2001) Improving safety in the Alaskan commercial fishing industry. *Int J Circumpolar Health* 60:705-713.**

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T4: Population Measures

Year	Vessels Lost	Persons on Board	Fatalities	Survivor Rate
1991	**39**	**93**	**25**	**73%**
1992	44	113	26	77%
1993	**24**	**83**	**14**	**83%**
1994	36	131	4	97%
1995	**26**	**106**	**11**	**90%**
1996	39	114	13	89%
1997	**31**	**84**	**1**	**99%**
1998	37	124	9	93%
1999	**28**	**104**	**11**	**89%**

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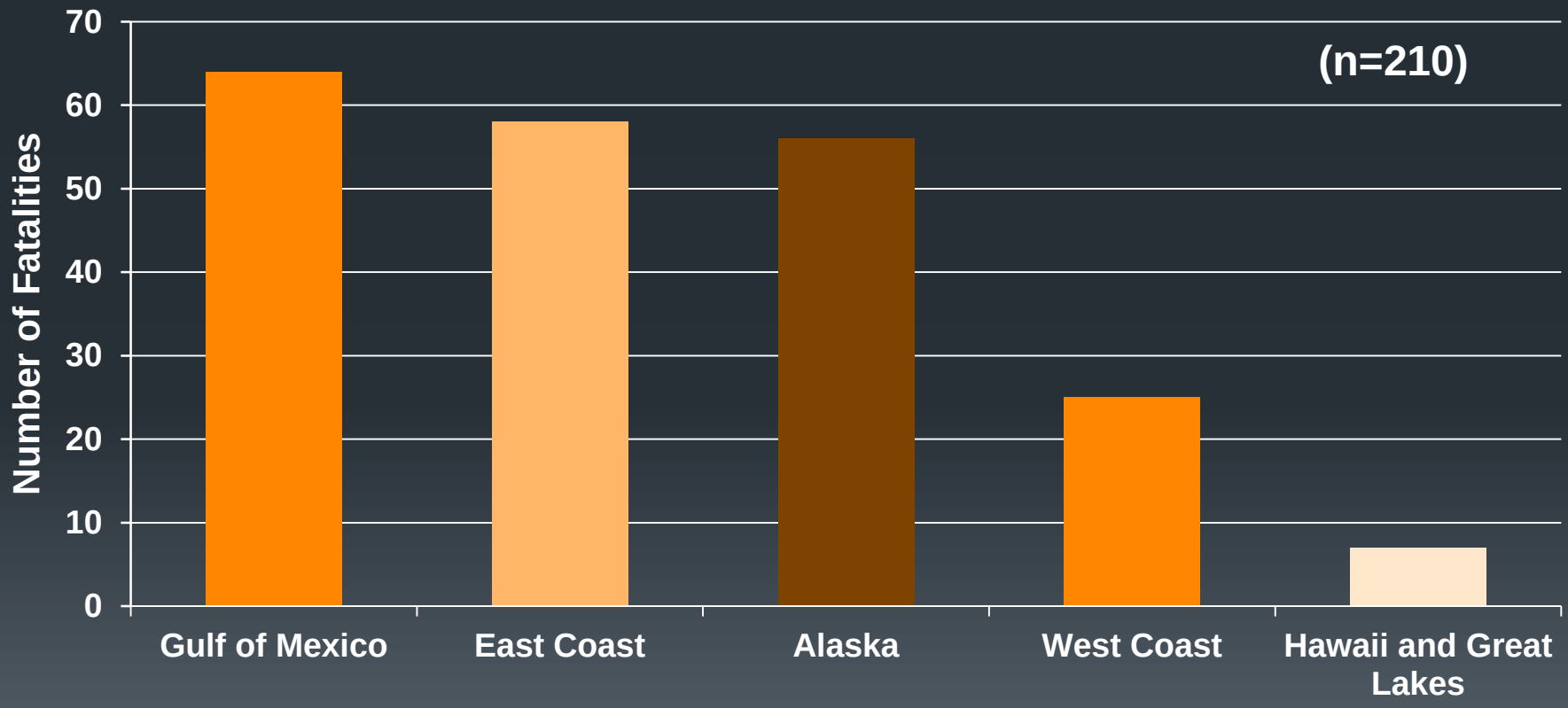
Source: Lincoln J, Husberg B, Conway G. (2001) Improving safety in the Alaskan commercial fishing industry. Int J Circumpolar Health 60:705-713.

Fatal Falls Overboard by Region: 2000-2014



No PFDs!

Fisherman:

"Why doesn't somebody buy a bunch of PFDs and see which ones guys like to wear?"

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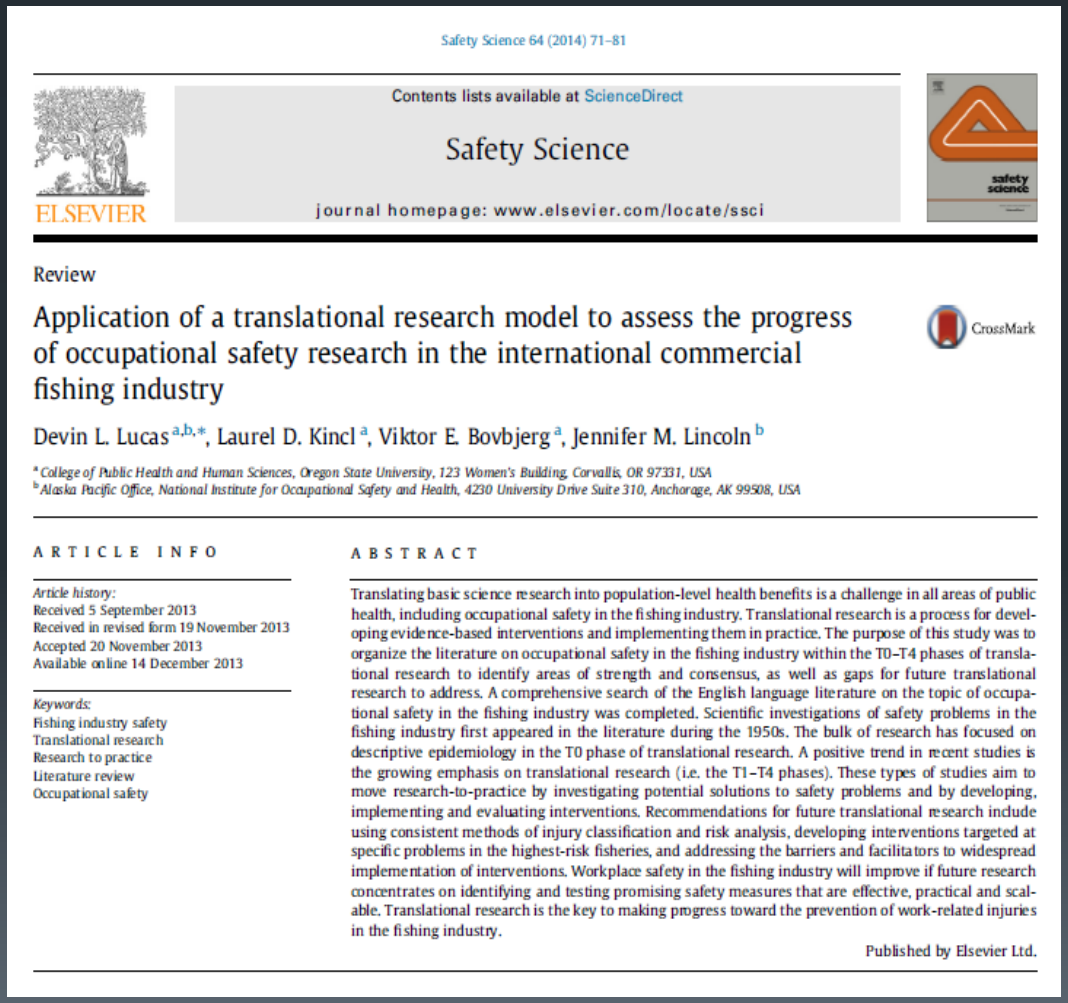
Translational Success Stories – Commercial Fishing



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Review

Application of a translational research model to assess the progress of occupational safety research in the international commercial fishing industry

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ABSTRACT

Translating basic science research into population-level health benefits is a challenge in all areas of public health, including occupational safety in the fishing industry. Translational research is a process for developing evidence-based interventions and implementing them in practice. The purpose of this study was to organize the literature on occupational safety in the fishing industry within the T0–T4 phases of translational research to identify areas of strength and consensus, as well as gaps for future translational research to address. A comprehensive search of the English language literature on the topic of occupational safety in the fishing industry was completed. Scientific investigations of safety problems in the fishing industry first appeared in the literature during the 1950s. The bulk of research has focused on descriptive epidemiology in the T0 phase of translational research. A positive trend in recent studies is the growing emphasis on translational research (i.e. the T1–T4 phases). These types of studies aim to move research-to-practice by investigating potential solutions to safety problems and by developing, implementing and evaluating interventions. Recommendations for future translational research include using consistent methods of injury classification and risk analysis, developing interventions targeted at specific problems in the highest-risk fisheries, and addressing the barriers and facilitators to widespread implementation of interventions. Workplace safety in the fishing industry will improve if future research concentrates on identifying and testing promising safety measures that are effective, practical and scalable. Translational research is the key to making progress toward the prevention of work-related injuries in the fishing industry.

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Translational Success Stories – Construction

Eileen Betit, BA

CPWR - The Center for Construction Research and Training

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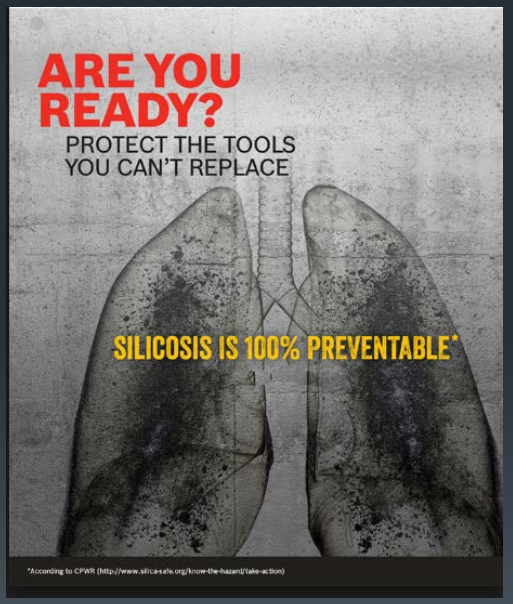
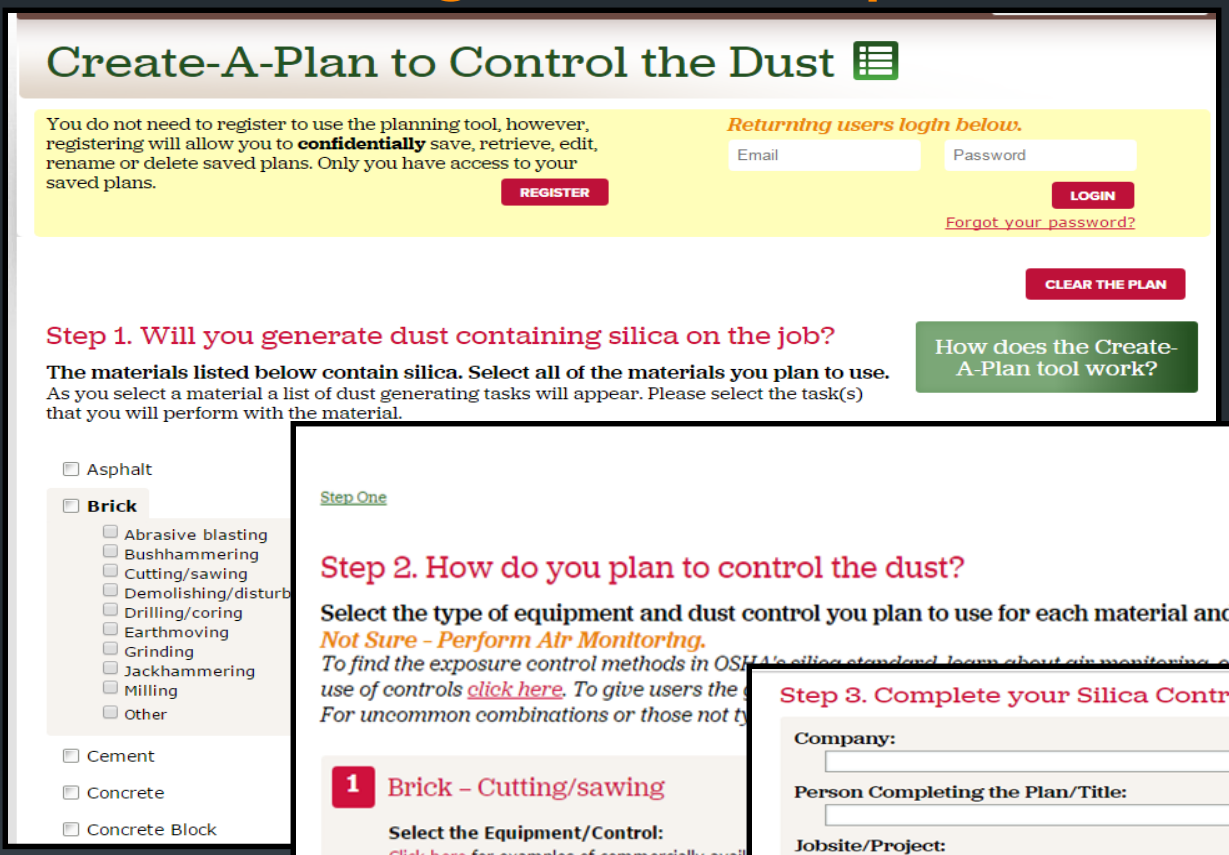
Reducing Silica Exposure

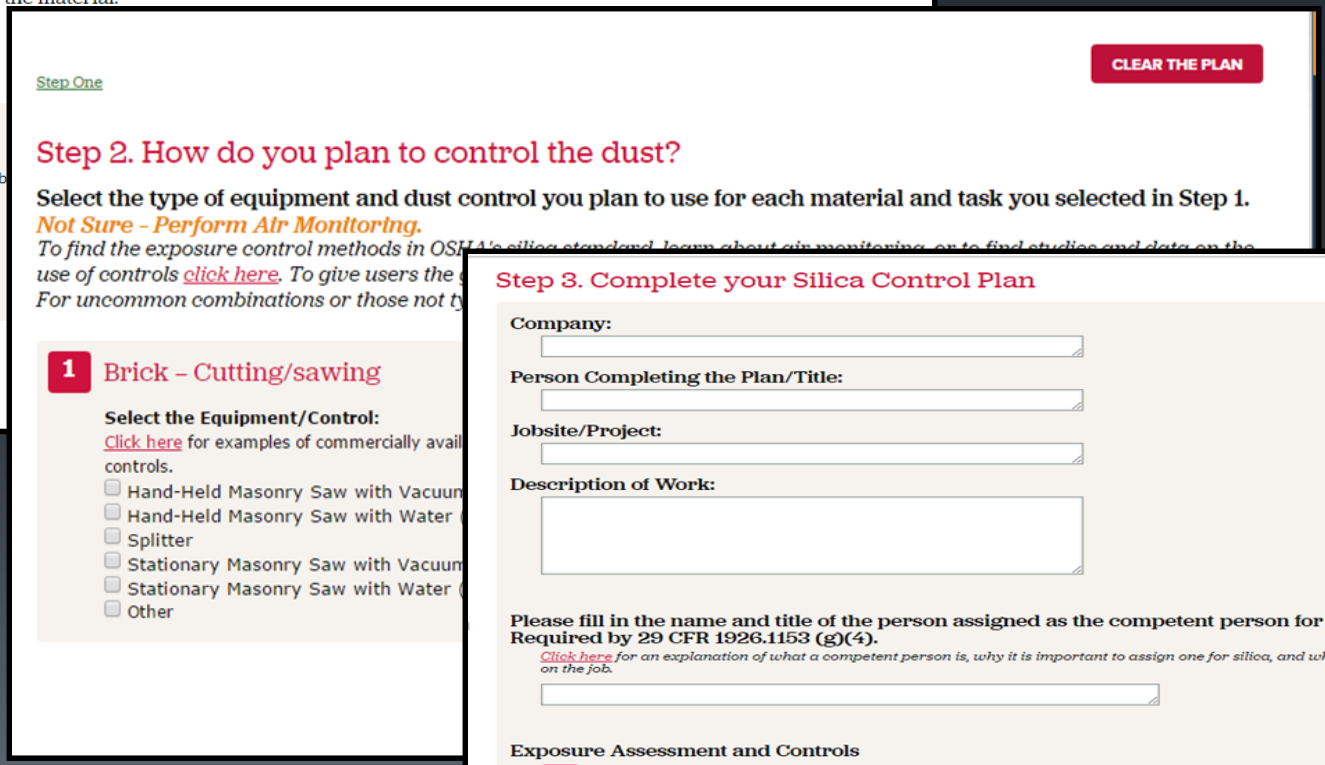
Using Technology to Promote Best Practices…

- Research-based solutions to silica exposure:
  - -Water
  - -LEV
- Adoption challenges:
  - -Unaware of seriousness of hazard
  - -Unaware of the research
  - -Perception solutions are not available/not feasible
- What we learned from workers/contractors
  - -Difficult to find information
  - -Available information is too general/complicated
  - -Make it easy
  - -Generate a ‘take-away’
- What we proposed
  - -A one-stop website/resource and planning tool



Reducing Silica Exposure



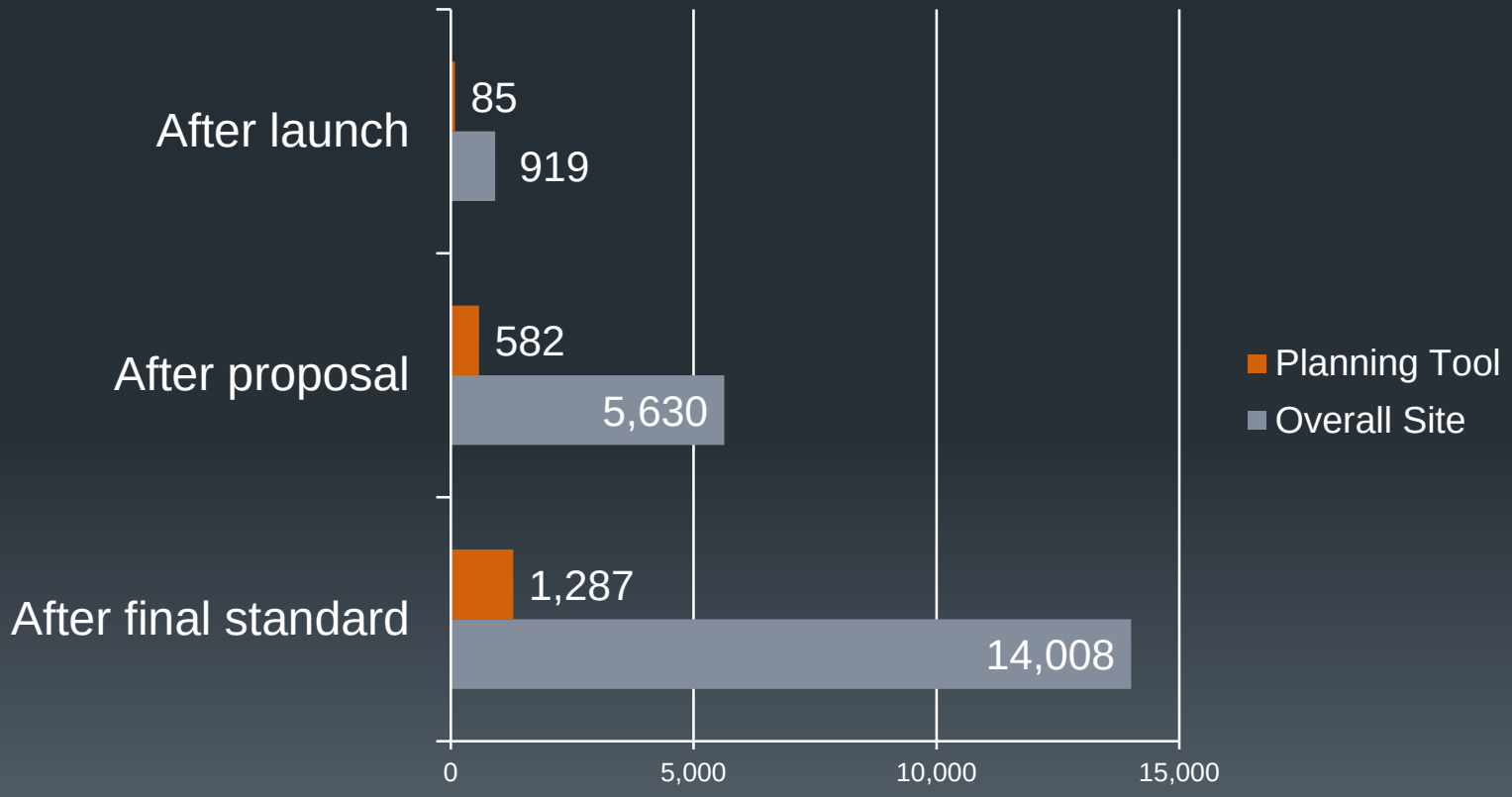


Key Steps and Progress

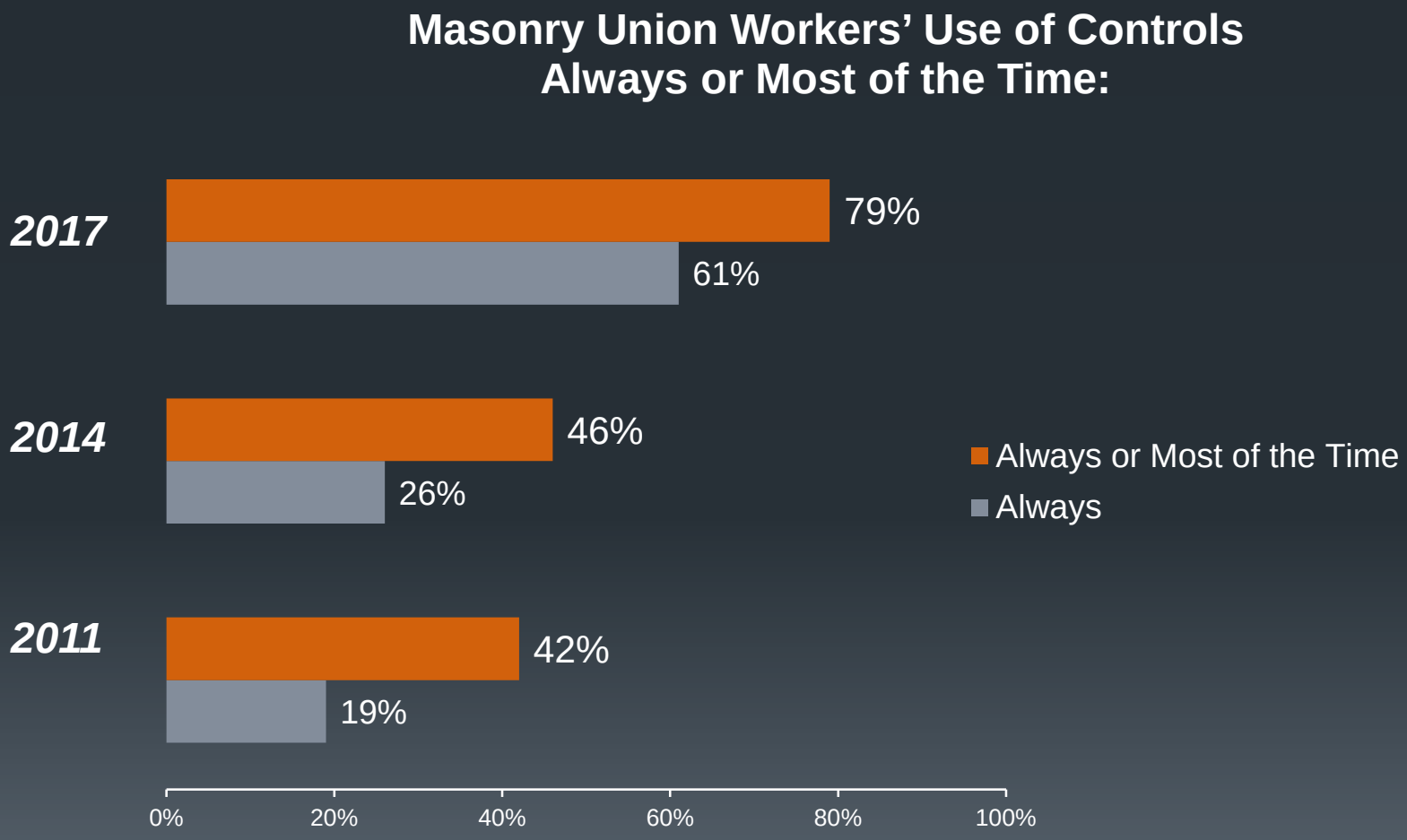
- 2011-2012 developed and launched the website
  - -Involved workers and contractors, manufacturers and researchers
  - -Launched with target audience involvement
- 2013 OSHA announces proposed Silica standard
  - -Website used in testimony
  - -Worked with stakeholders to expand content
  - -Promoted in social media, presentations, articles, trade pubs
- 2016 OSHA releases final standard
  - -Website cited in preamble as evidence of feasibility
  - -OSHA recommends website as tool to aid in compliance
  - -Manufacturers and insurance companies promote website with clients

T4: Population Measures

Average sessions per month since launch…



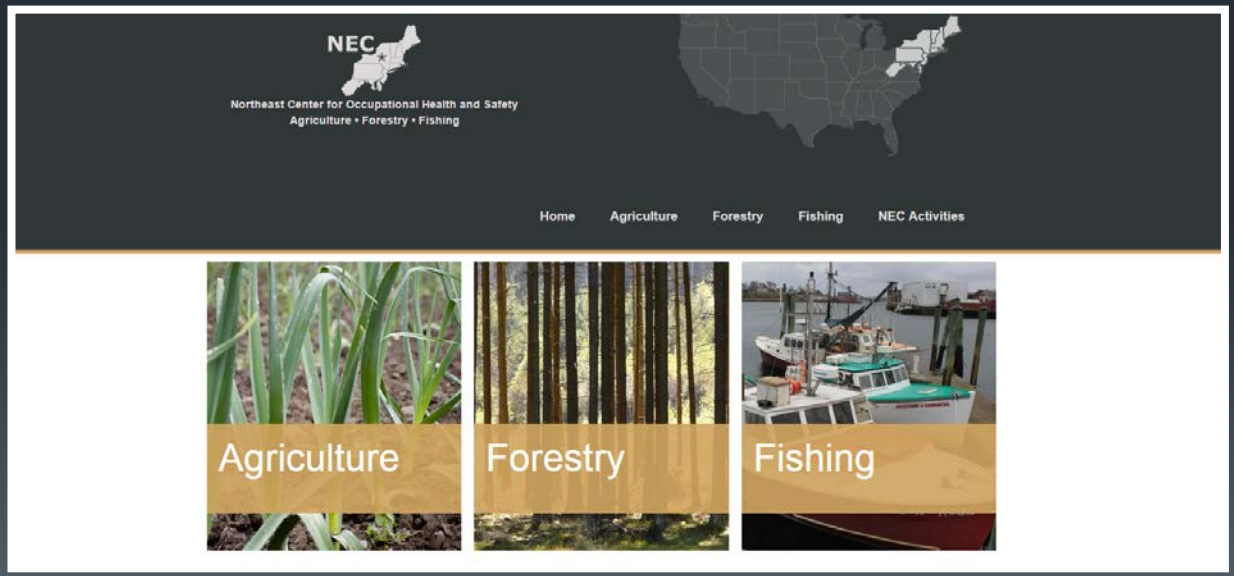
T4: Population Measures



Translational Success Stories – Agriculture

Julie Sorensen, PhD

The Northeast Center for Occupational Health and Safety



Tractor Overturns in the US

- Most common cause of death on US farms
- Preventable with the proper use of ROPS
- Several efforts in the US to encourage ROPS
  - -Education
  - -Tractor Safety Initiative
  - -Rebate Programs

The ROPS Rebate Program: How it Works

Call the ROPS Hotline 1-877-ROPS-R4U or visit www.ropsr4u.com

Complete Intake Form

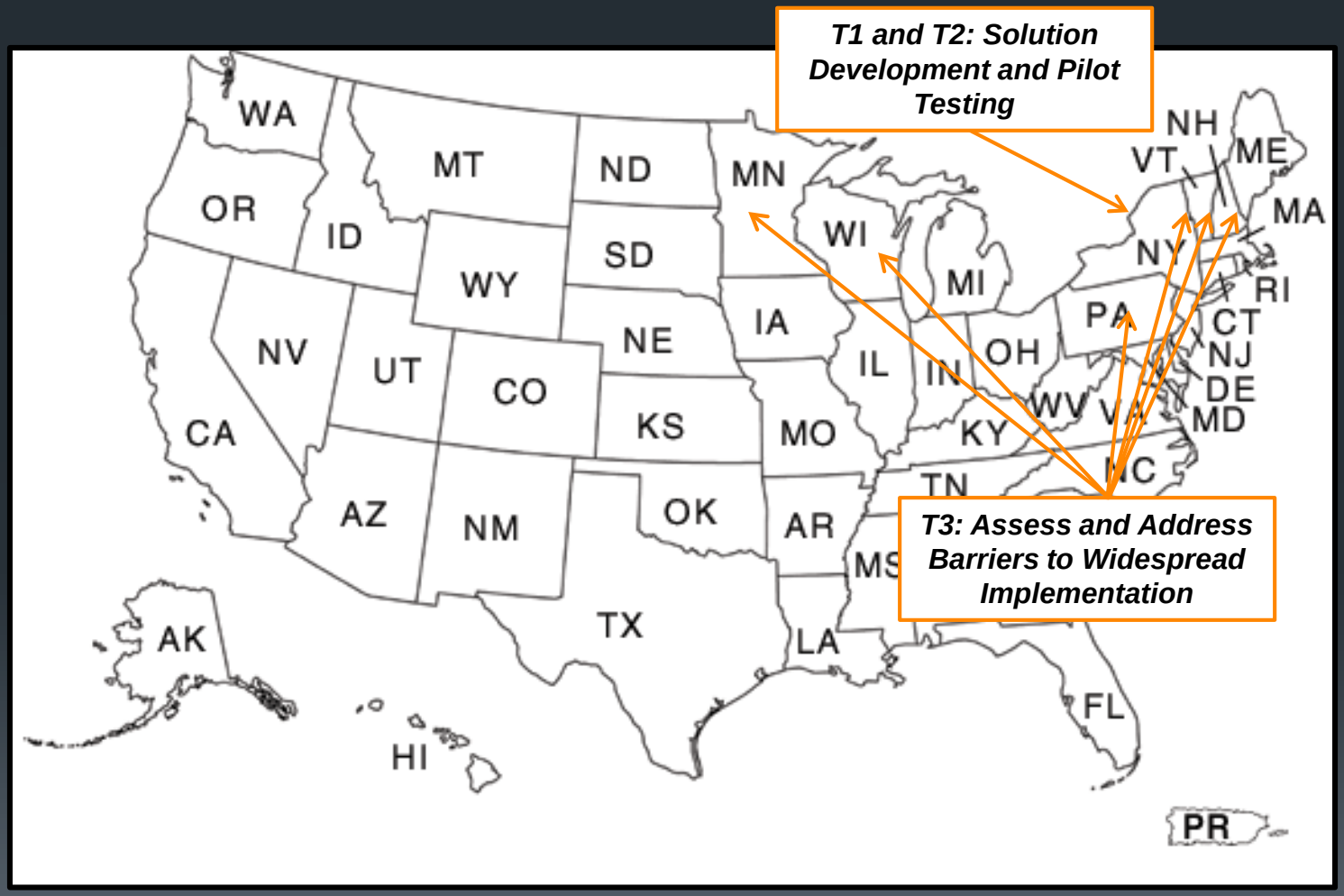
List of price estimates and ROPS sources are sent

Call ROPS Staff for pre-approval and to confirm ROPS placed on order

Send proof of purchase and installation

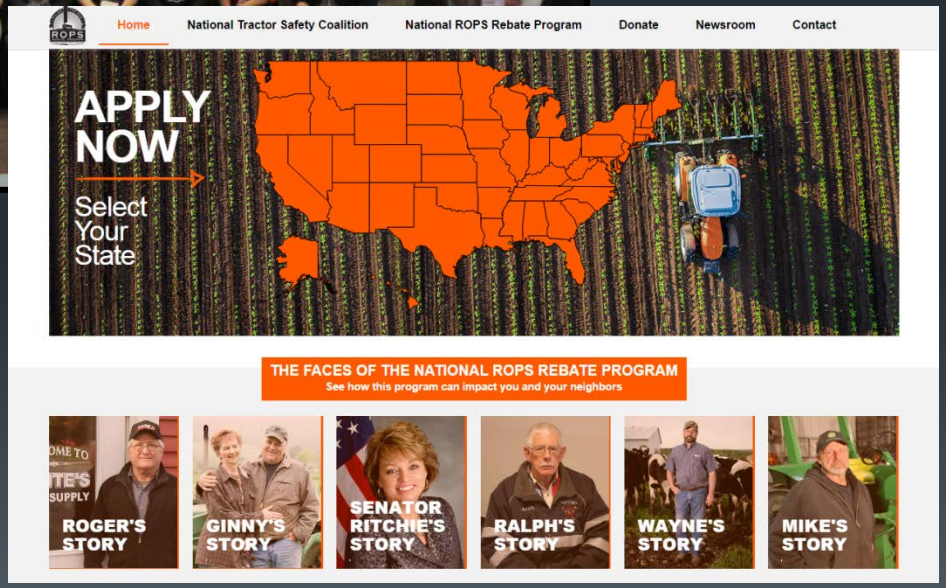
Rebate check mailed within 30 days

T0-T3 Implementation Progression



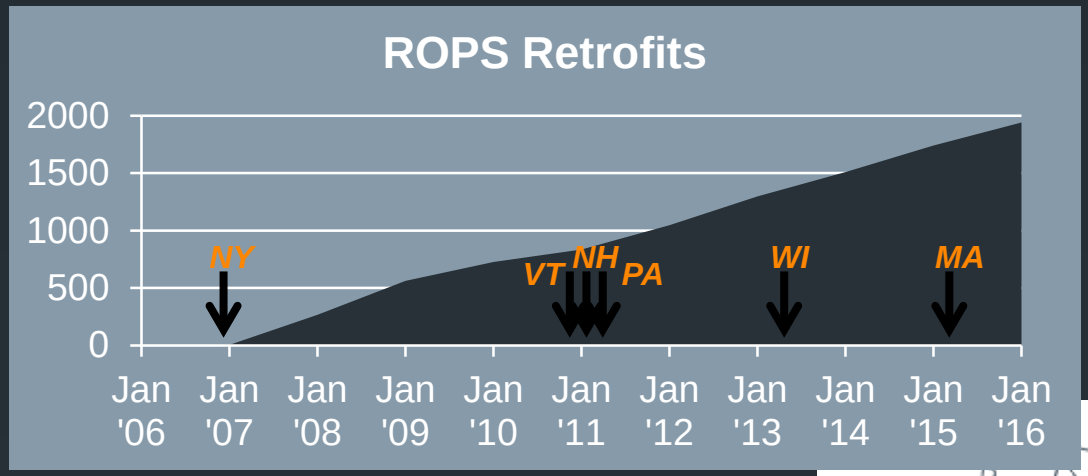
National Expansion

National Tractor Safety Coalition



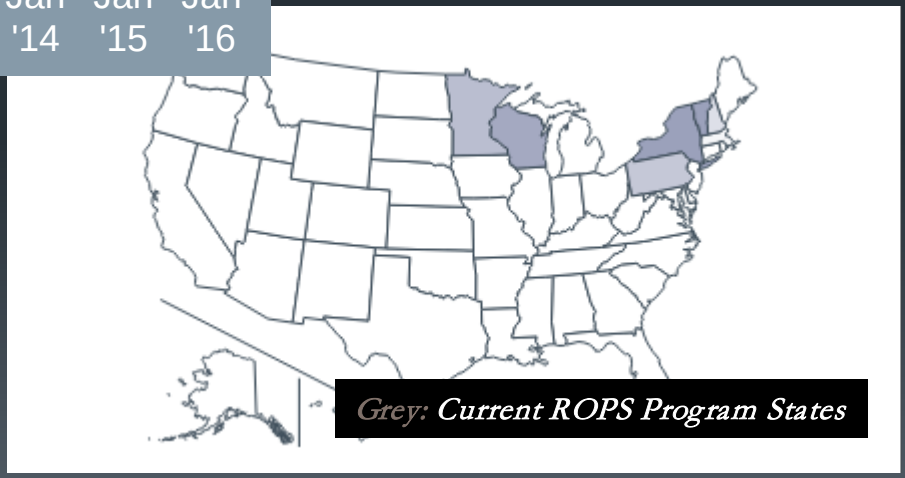
National ROPS Rebate Program

T4: Population Measures



19 overturns and nearly 200 close calls reported by participants

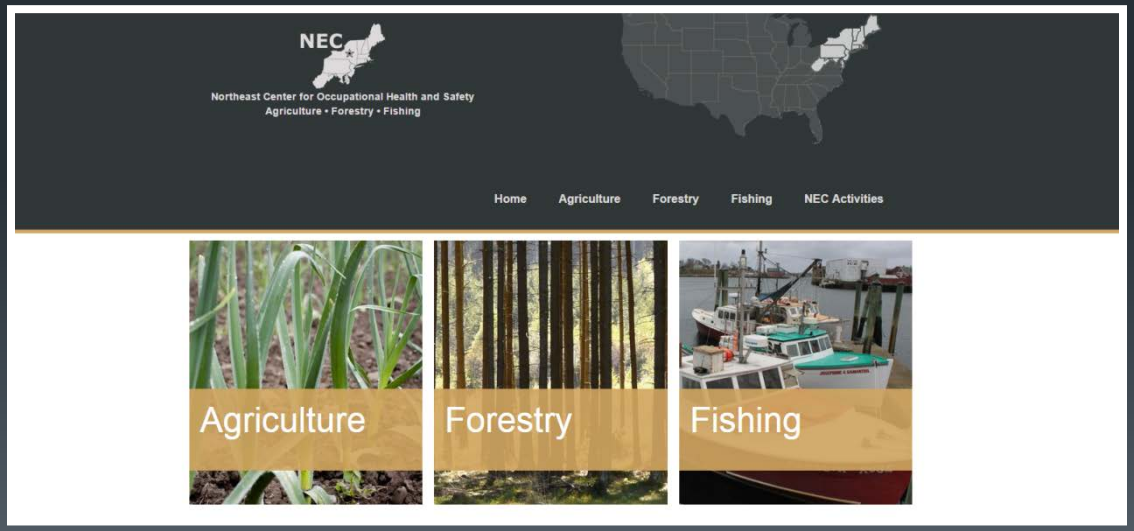
99% of farmers would recommend the program to others



What Contextual Factors Ensure Successful Implementation of Worksite Solutions?

Anne Gadomski, MD, MPH

Northeast Center for OSH

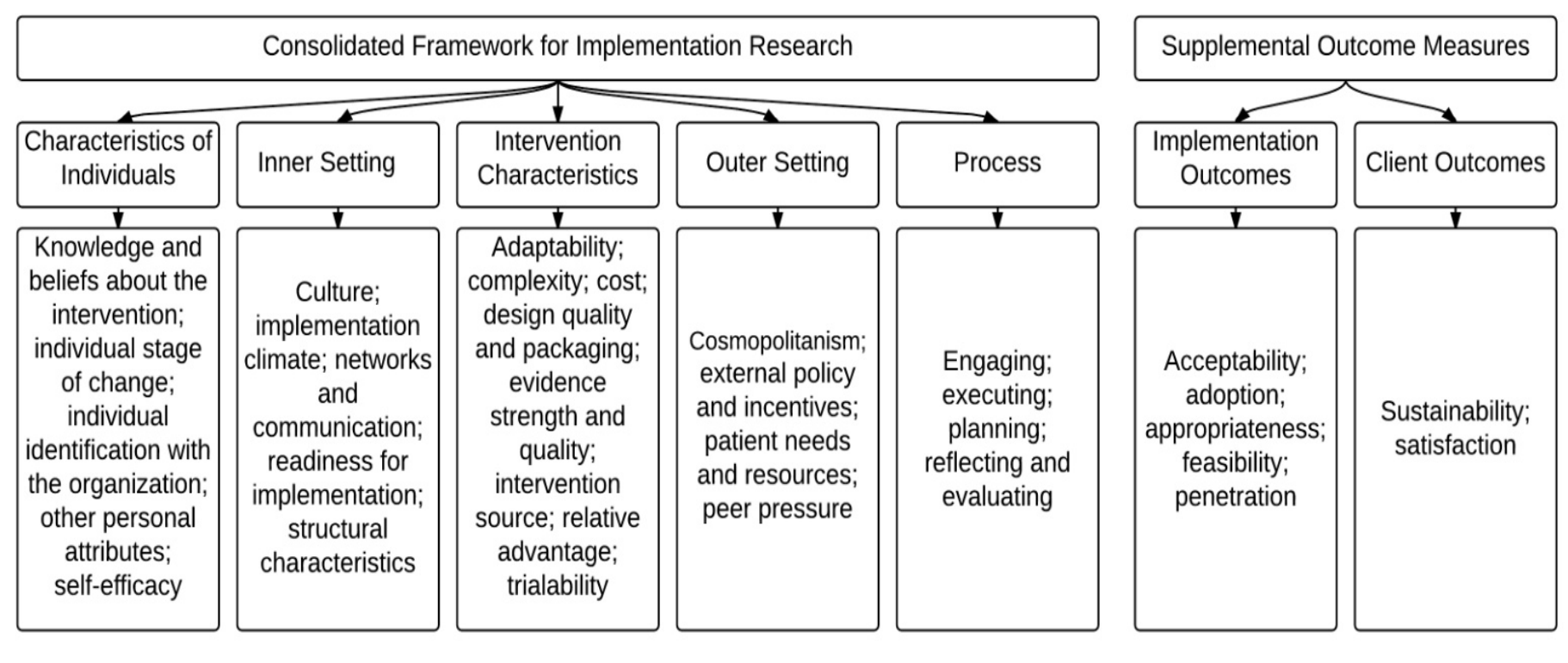


CDC Workplace Safety and Health NIOSH

Important Factors for Scaling Up

- Fixsen et al. (2005):
  - -Attitudes about EBIs, motivational readiness, community resources, staff attributes, organizational climate, stages of community readiness
- Rabin and Brownson (2012):
  - -Clear distinction between fixed intervention components (*implementation fidelity*) and flexible components (*adaptation*).
- Aarons et al. (2012):
  - -A strong leader who encourages the use of evidence to guide practice and adherence to that vision.
- Spoth et al. (2013):
  - -cost tracking/analysis tools that facilitate accurate cost projections
  - -technical assistance that incorporates on-the-job coaching

The Consolidated Framework for Implementation Research (CFIR)



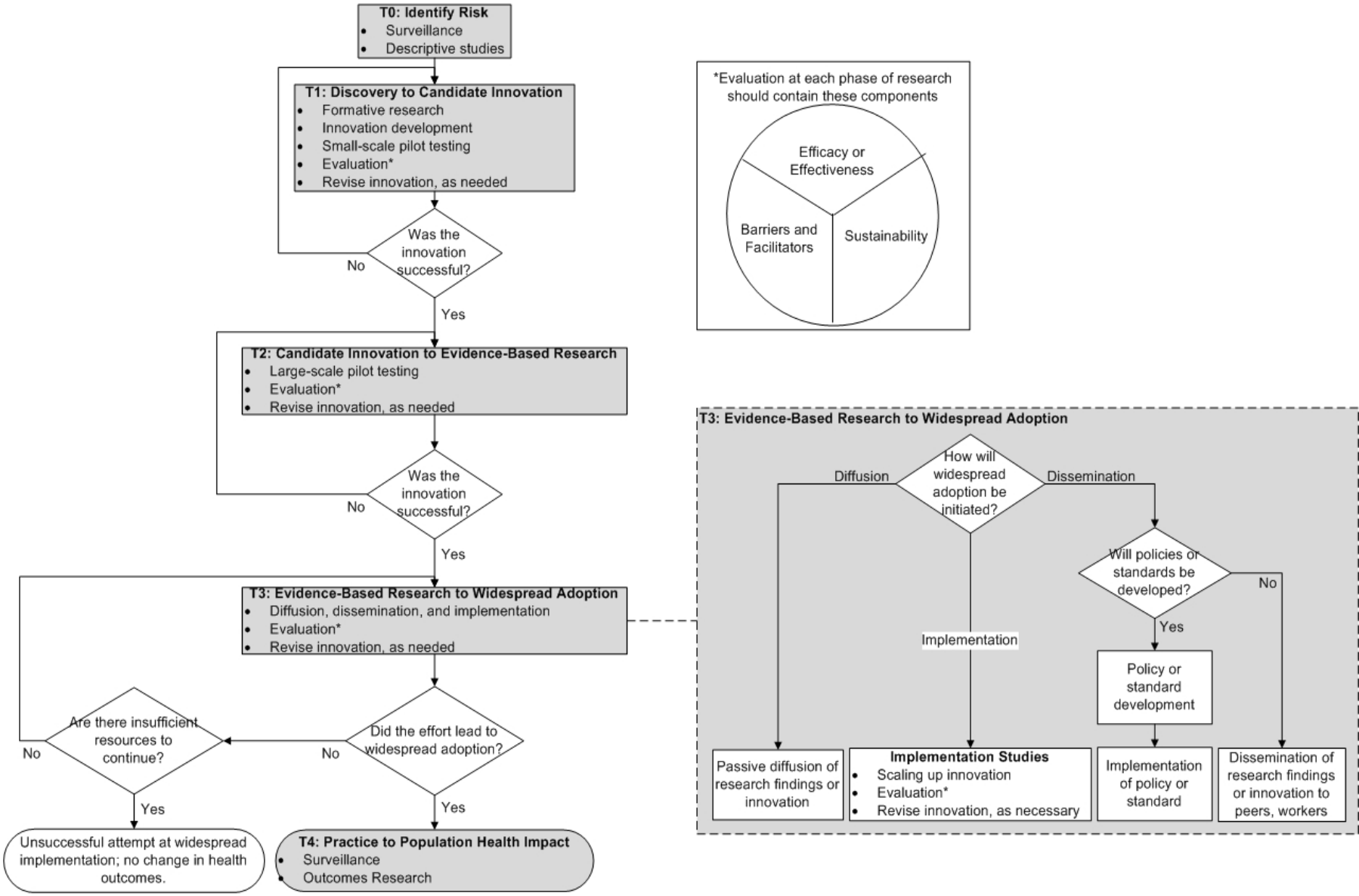
From: Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. 2009;4:50. Center for Clinical Management Research. Consolidated Framework for Implementation Research. 2015; http://cfirguide.org/. Accessed September 15, 2015.

Models, Measures and Methods

Using the Consolidated Framework for Implementation Research (CFIR) to transition to T4 stage (National ROPS Rebate Program):

- CFIR model to a non-clinical setting
- Add two categories (client outcomes and implementation outcomes)
- Use *Think Aloud* to update concepts so individuals from a wide-variety of backgrounds can understand and comment
- Survey the NRRP coalition (n =65) to rate constructs on a 5-point Likert scale "will not impact implementation" → "will strongly impact implementation"
- Use modified survey to assess implementation at 3 points during scale-up
- Relate strength of CFIR factors to program outcomes (ROPS shipments)

T_0 to T_4 Model Adaptations for OSH



In summary…

- *Translational research-the study of the process of research translation*

- *Factors for ensuring successful translation of research to the worksite:*

  -Tailoring solutions to our target populations
  -Multi-industry/stakeholder investment throughout the process
  -Multiple points of persuasion-make it easy/enforcement/benefits
  -Sustained funding agency investment
  -Promotion and advocacy (High Visibility)

Understanding Community Infrastructure and Capacity to Engage Community Agencies in Advancing Occupational Health Disparities Research

Jenny Hsin-Chun Tsai, PhD, ARNP, PMHCNS-BC, School of Nursing
Elaine Adams Thompson, PhD, RN, School of Nursing
Jerald Herting, PhD, Department of Sociology

NIOSH Expanding Research Partnerships: State of the Science
June 22, 2017

UNIVERSITY of WASHINGTON

Presenter Disclosures

> No relationships to disclose

> Content is solely responsibility of the authors and does not necessarily represent the official views of NIOSH, the funding agency

Background and Issues

- Changing demographics of the US workforce and nature of work
- Immigrant workers disproportionally employed in low-wage, high health risk jobs
- Conventional worksite prevention approaches relatively ineffective in reaching low-wage immigrant workers
- Alternative approaches needed to address occupational health disparities

Background and Issues

- Community-based collaborative approaches have received increasing attention as a promising alternative
- Little guidance, however, in the literature regarding:
  - How to engage community resources such as immigrant community institutions, nonprofits in the process to maximize “research to practice” effectiveness?
  - How to systematically identify community partners to disseminate worker health knowledge in the community?
  - How to translate research findings to non-worksites for immigrant worker health?

Purpose of this Presentation

> Illustrate an alternative approach to advance research for immigrant worker health, using two community based research projects (R21) with Chinese immigrant workers as an exemplar

Grants: NIOSH R21 OH009955 & OH010670

Overall Goal of the Studies

- To generate new knowledge to guide community partner selection and intervention design to increase worker health program diffusion and sustainability in communities:
  - Who engages in the delivery of information and services to advance Chinese immigrant worker health
  - What are ways to disseminate interventions that capitalize on community resources and at the same time put minimal demand on community resources

Study Description

- Interagency Network Study (N=36)
  - Characterized interagency connections and agency roles in community networks
  - Assessed organizational capacity (commitment, resources, flexibility) specific to Chinese immigrant worker health
- Integrating Worker Health Education Study (N=26)
  - Identified factors pertinent to agency programmatic decisions
  - Assessed the integration process for *Basic Worker Health Education* (WHEB) diffusion and sustainability at diverse community settings

Study Description

Study Samples

Comm. Sectors	Chinese service (SER)	Chinese faith-based (FBO)	Pan-Asian service (PAN)	Pan-ethnic nonprofit (NON)	Public/ Gov (PUB)	Union (UNI)
Network Study	4	10	5	11	4	2
WHE Study	4	11	3	9	--	--

Procedures

Network study: Joint interview with administrator & staff person from each agency

WHE Study: 2 Phases

1. Interview with middle or upper level administrator to identify factors for programmatic decisions;
2. Intervention implementation with 2 SER, 2 FBO, 2 PAN, and 2 NON agencies.

Knowledge We Gained...

Community Infrastructure & Capacity for Chinese Immigrant Worker Health

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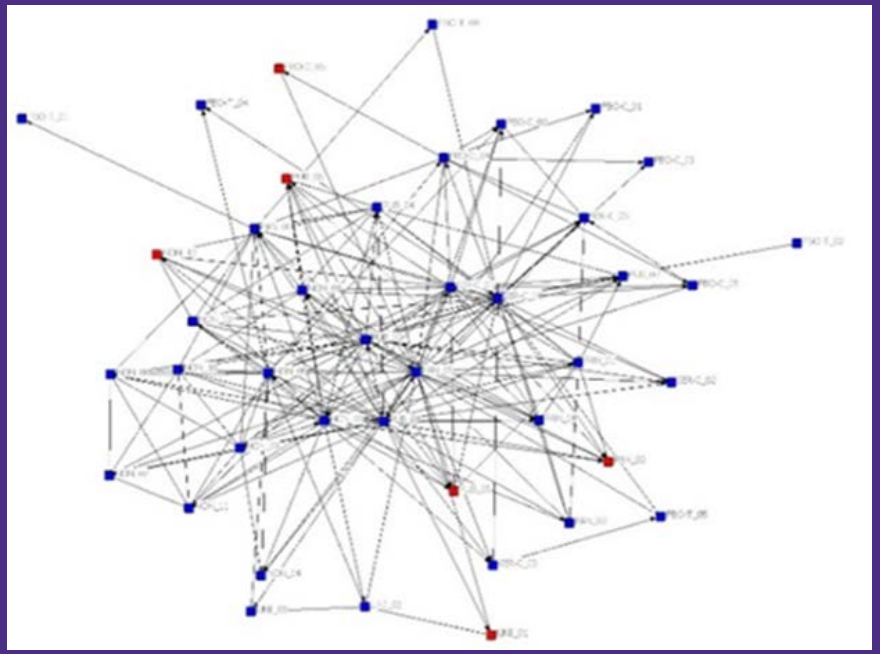
Sharing Information: Primary Reason for Interagency Connections

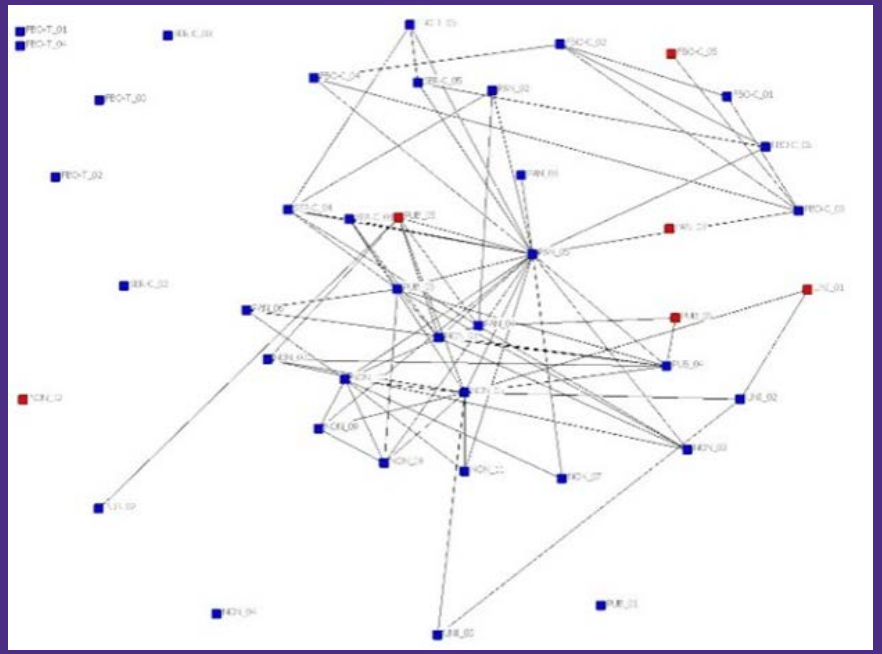
LEGEND

■ = Participating agency node; ■ = Declined agency node

Straight line = inter-agency link; **Arrow** = direction of link



Information sharing (density=0.16)

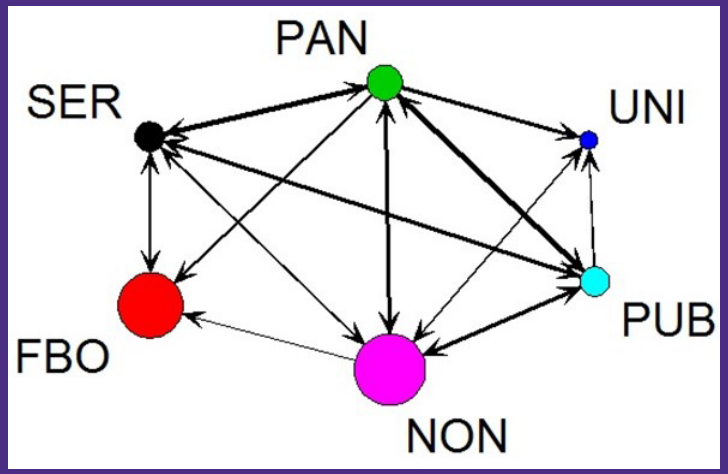


Joint political actions (density=0.06)

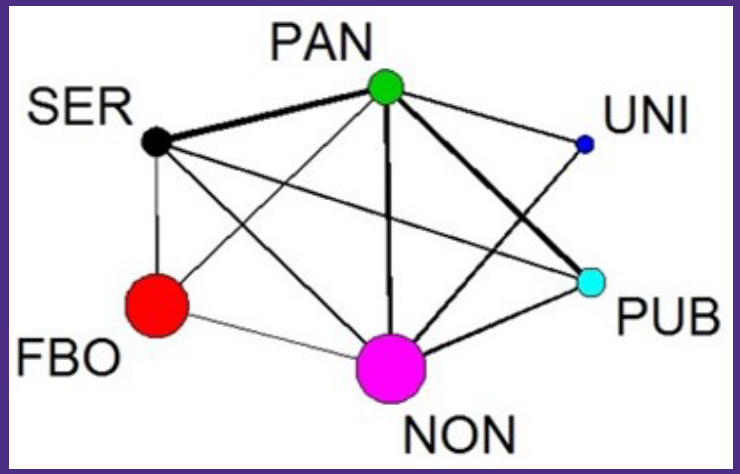
Strongest Ties Predominately Service, Nonprofit, and Public Sectors

- Chinese and Pan-Asian service sectors: strongest interconnectness
- Chinese faith-based and union sectors: relatively weakest links with other sectors

Legend:
Colored circle=sector node
Size of circle=sample size in sector
Line=inter-sector tie
Line width=strength of tie
Arrowhead=direction of tie



Directed cross-sector network for information and resource sharing



Undirected, cross-sector network for referrals, joint programs, joint political actions, & service contracts.

(Tsai & Petrescu-Prahova, 2016)

Central or Gatekeeper Positions Limited to Service-Oriented Agencies

Central Positions

Type of relation	First	Second	Third
Info. Sharing	Pan Asian 05	Public/Gov 01	Chinese Srv. 04
Resource Sharing	Pan Asian 05	Nonprofit 06	Public/Gov 03
Referrals	Pan Asian 05	Chinese Srv. 04	Nonprofit 05
Joint Programs	Pan Asian 05	Nonprofit 05	Nonprofit 10
Joint Political Actions	Pan Asian 05	Nonprofit 05	Nonprofit 09
Service Contracts	Nonprofit 03	Pan Asian 05	Public/Gov 03

Gatekeeper Positions

Type of relation	First	Second	Third
Info. Sharing	Pan Asian 05	Nonprofit 05	Chinese Srv. 01
Resource Sharing	Pan Asian 05	Public/Gov 03	Chinese Srv. 04
Referrals	Pan Asian 05	Chinese Srv. 04	Nonprofit 02
Joint Programs	Pan Asian 05	Nonprofit 05	Chinese church 03
Joint Political Actions	Pan Asian 05	Pan Asian 04	Nonprofit 09
Service Contracts	Nonprofit 03	Pan Asian 05	Nonprofit 05

(Tsai & Petrescu-Prahova, 2016)

Ratings on Organizational Capacity for Agencies in Central or Gatekeeper Positions

Agency in Central or Gatekeeper Positions	Commitment (4 indicators)	Resources (4 indicators)	Flexibility (3 indicators)
Pan Asian 05	High	Low Medium	High Medium
Nonprofit 05	High	Low	High
Chinese Service 04	High	High	High
Public/Gov. 03	High	Low	High
Public/Gov. 04	High Medium	High	Low Medium

Note. High=in the top quartertile; Low=in the bottom quartertile; Low medium=between the 25th and 50th percentiles; High medium=between the 50th and 75th percentiles

Agencies in central or gatekeeper positions showed various levels of organizational capacity.

Engage Non-Governmental, Community Agencies in Chinese Immigrant Worker Health Research and Education Delivery

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Factors Influencing Agency Decisions on Program Adoption

- Intra-organizational factors:
  - Organizational mission
  - Staffing level
  - Organizational structure
  - Needs of their clients or service users
  - Funding
- Extra-organizational factors:
  - Needs of the communities or populations they serve
  - Services available at other agencies
  - Funder expectations

Challenges in Engagement

- Multiple phone “tags” required before actual connections
- Agency personnel changes
- Agency website contact information insufficient to initiate study invitation process
- Agency unfamiliar with research

Challenges in Engagement

- Inconvenient or poor timing for agency participation
- Agency unable to conceive the relevance of or fit with study goals
- Concerns about demands on staff
- Concerns about clients' perceived relevance for their primary reason for visiting the agency
- Uncertain about feasible mechanisms to engage Chinese immigrants at the agency to deliver *Basic Worker Health Education*

Solutions for Successful Engagement

- Persistence
- Broad data collection windows
- Ongoing support to provide assistance to research staff in developing effective strategies to facilitate recruitment and reduce frustration
- Create study-specific FAQs and communication templates for effective recruitment guidance
- Tailor communication strategies to help agencies understand the research project
- Brainstorm with agency staff to find ways to integrate the interventions

Summary and Implications

Our research provides critical new information

> Community potential to

- Build on current interagency or cross-sector connections
- Disseminate immigrant worker health interventions
- Strengthen community infrastructure and capacity to promote immigrant worker health

Summary and Implications

- Application of interagency network analysis and measures of organizational capacity for systematic assessment of community infrastructure and identification of potential partners
- Importance of working *within* agency organizational context to minimize demands on the agency, increase buy-in, and foster sustainability of immigrant worker health interventions

Thank you. Questions?

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