

A Case in Full

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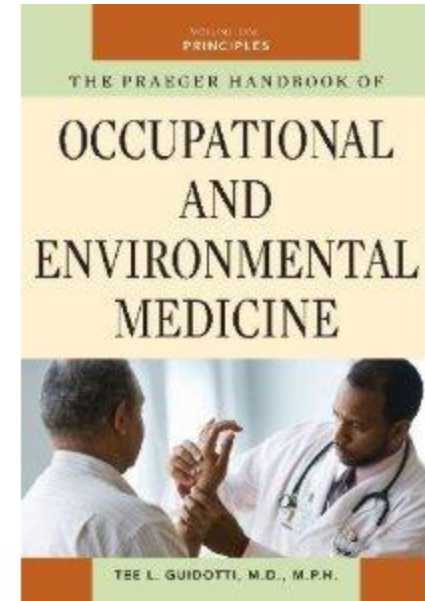
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Disclosure

- Tee L. Guidotti is a practicing occupational and environmental medical specialist, currently involved in all aspects of case management.
- He is the author of *The Praeger Handbook of Occupational and Environmental Medicine*, which is not for sale at this conference.
- Aspects of this case have been altered for didactic purposes but the clinical details are accurate.



HPI

- 48 yo male
- Works as a helper in installing energy-efficient seals and insulation and retrofitting older buildings for energy efficiency
- Progressive cough, shortness of breath, voice problems for 3 weeks
 - Occasional wheezing
 - Now constant
 - Worse at work
 - Exacerbated by:
 - cold weather,
 - passive exposure to irritants

BC Cancer Research Center: A
LEED Gold Building In Vancouver

www.metaefficient.com

PMH

- In general good health
- No medications or illicit drugs, alternative/herbal meds
- No atopy, respiratory dz, dermatitis, fever, weight loss
- No tobacco, EtOH
- FH: No atopy, asthma. Married, one daughter 12 yo.
- Occupational history:
 - Caulking
 - Polyurethane foam insulation
 - Previously glazier's helper
 - This is a well-paying job.

Clinical Data

- Lab tests noncontributory
- CXR
- PFTs: Mixed
 - Obstructive defect, no air trapping
 - Restrictive defect
 - Reduced midflows
 - Unfortunately, tracing is not available.



So what was he exposed to?

Job titles often don't help.

- Job titles vary:
 - Glazier
 - Energy efficiency technician
 - Window installer (not a software application)
- Trades are different.
- Best to ask patient to describe what they actually do.

The MSDS

- Material Safety Data Sheets are like package inserts:
 - Overwhelm with information
 - Tend to downplay common problems
 - Tend to play up problems that involve liability
- Must be interpreted knowledgeably

The MSDS is part of a system.

Material Safety Data Sheets

The MSDS

- Getting easier to use.
- Required under OSHA Hazard Communication Standard:
 - Conversion to “Globally Harmonized System”
 - US system for handling chemicals will change soon.
 - May omit some proprietary components but physicians may access the information

Standardization

1. Identification
2. Hazard(s) identification
3. Composition/information on ingredients
4. First-aid measures
5. Fire-fighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information

Occupational History

- Job involved weatherproofing, waterproofing, reducing heat loss through insulation
- Used many products based on polyurethanes:
 - Paints
 - Polyurethane foam insulation (high R factor)
 - Caulk
- Polyurethanes require *isocyanates*
- Used it in *relatively* enclosed spaces
 - Differentiate from a true “confined space”
 - Buildings under construction – HVAC not functioning
 - Inside corners, crawl spaces, utility areas
- PPE not easy to use: temperature, humidity; not compliant
- Wore work clothes home at the end of the day

Power caulking.

Caulking

A Paric construction worker applies caulk to the main doorway of the new Grace Hill Water Tower Health Center, St. Louis. www.gracehill.org

What is the differential?

Differential Diagnosis

- Airways disease
 - Upper
 - Lower (bronchitis)
 - Variable (“asthma”)
- Interstitial disease
 - Pneumoconiosis
 - Hypersensitivity pneumonitis
 - Interstitial pneumonias
 - Idiopathic Pulmonary Fibrosis = UIP
 - Granulomatous dz
 - Drug reaction
 - Autoimmune
 - Infectious
 - Post-radiation
 - Lymphagiitic cancer
 - Graft v. host

This Case

- Upper airway irritation
- Occupational asthma
 - Sensitization
 - Irritant induced
 - Chronic, multiple exposures
 - Reactive airways dysfunction syndrome (single incident)
 - Irritant bronchitis + reactive airways
- Hypersensitivity pneumonitis

What is “occupational asthma”?

Sensitization

- Antigen types:
 - High molecular weight:
 - Latex
 - Proteolytic enzymes
 - Laboratory worker asthma
 - Low molecular weight:
 - Isocyanates
 - Trimellitic anhydride
 - Metal salts
- Variable presentation
- Requires removal

Irritation

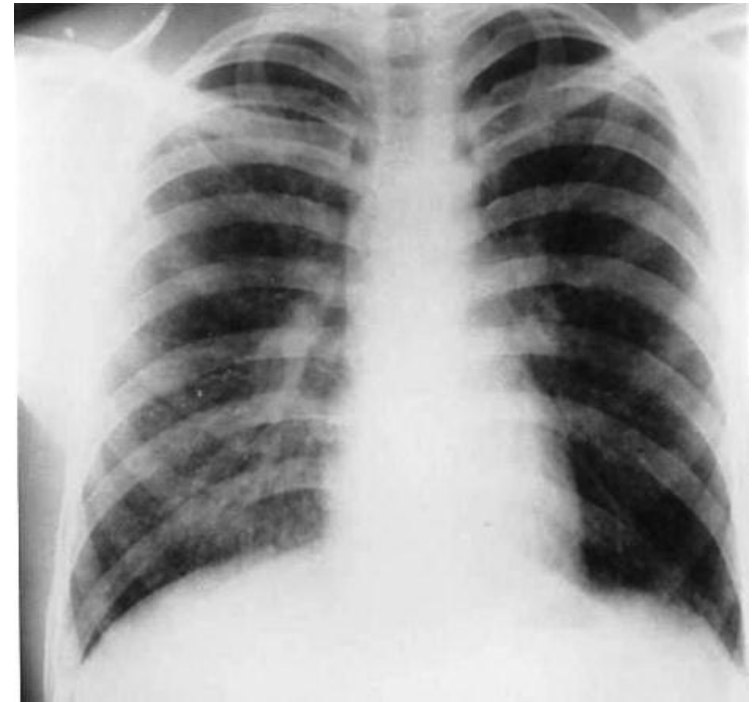
- Airways irritation (heavy exposure):
 - Irritant-induced (general)
 - Reactive airways dysfunction syndrome (discreet exposure)
- Aggravational
 - Existing reactive airways
 - Atopy, latent airways reactivity
- “Asthmatic bronchitis”

Be careful:

“Aggravation” and “exacerabation” have special meanings in workers’ compensation.

What is a hypersensitivity pneumonitis?

- Prototype disorder is “farmer’s lung”
 - ≠ “silo-fillers’ disease”
- Infiltrate → fibrosis
- Cytokine-mediated disease
- Provoked by persistent antigen
- Often preceded by airways prodrome
- Most common antigens seen today:
 - Thermophilic actinomycetes (humidifiers)
 - Molds (esp. refurbishing buildings)
 - Bird antigens (“pigeon breeders’ lung”)
 - Isocyanates
 - Trimellitic anhydrides



A case of farmers’ lung from San Diego.

Subsequent events

- Treated for asthma (referred to Pulmonary service for F/U)
Rx montelukast + formoterol + budesonide
- Patient's condition stabilized on "medical removal" (term of art for removing him from his workplace or work station).
- Subsequent events in his history:
 - Fitness for duty
 - Impairment and eligibility for workers' compensation
- Implications for the family
- Subsequent events in history of this case
 - Occupational health protection
 - Environmental implications

Validation of the diagnosis

- Airways component
 - Methacholine challenge → No additional information
 - Antigen-specific bronchoprovocation → Contraindicated because of risk of sensitization
- Parenchymal component
 - Antigen identification (through serology, RAST, skin prick, etc.) → not available for isocyanates or most small MW antigens
 - HRCT → No additional information
 - Biopsy → Low benefit to risk ratio, nonspecific
- Clinical diagnosis and observation
 - Clinical judgment + exposure history
 - Natural history of disorder

Airways Disorders and HP due to Isocyanates

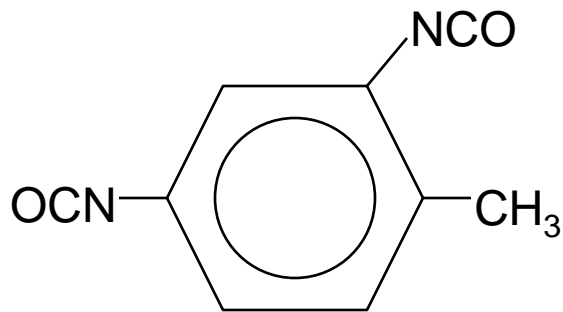
Airways Disorders

- Isocyanates are the leading small MW cause of occupational asthma
- May also irritate airways, provoking response
 - Exacerbates existing airways reactivity (nonoccupational asthma)
 - May induce RADS
- No provocative test available: contraindicated

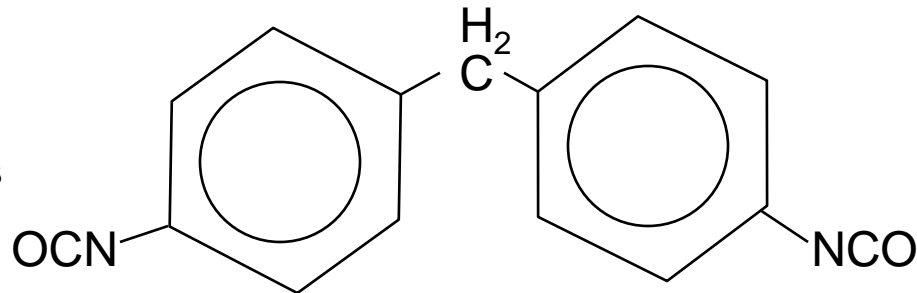
Hypersensitivity Pneumonitis

- Isocyanate acts as hapten:
$$R-NCO + \text{protein} \rightarrow \text{complete antigen}$$
- Initial inflammatory response
 - Fever, infiltrate
 - Cough, SOB
- Fibrosis

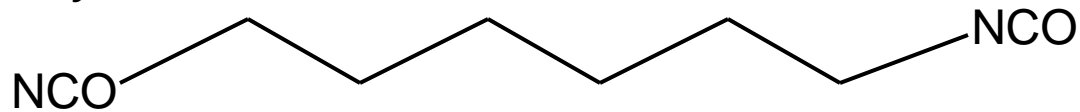
Isocyanates



*2,4-Toluene diisocyanate (TDI);
usually 80/20% between isomers*



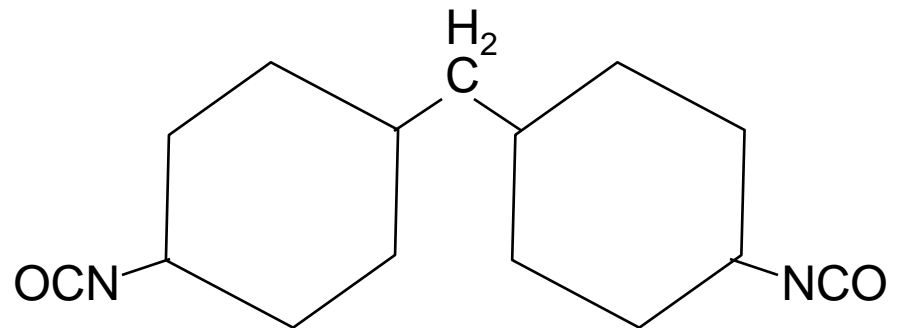
Diphenylmethane diisocyanate (MDI)



Hexamethylene diisocyanate (HDI)

Specialized for purpose:

- Aliphatic
- Cycloaliphatic
- Aromatic
- Other



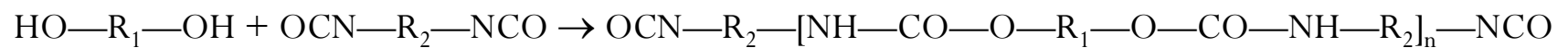
Bis(4-isocyanatocyclohexyl-methane) (H₁₂-MDI)

Isocyanate Products

- Paints
- Coatings
- Foams
 - Soft
 - Hard
 - Memory
 - Insulation
- Molded products
- Glues
- Caulk!

Properties of the Isocyanates

- Highly reactive, esp. with urethanes:
—NH—CO—O—
 - Can be nucleophiles or electrophiles!
- Significant but not high vapor pressure
- Forms polymeric cross-links with urethane polyols
- Unreacted isocyanate persists until outgassed.



Polyol

Isocyanate

Urethane

Usually in medicine, diagnosis is primary. Not here.

- Identification

- Diagnosis

- **Causation** →

- Functional evaluation

- Treatment

- Prognosis

- sentinel event monitoring
- causation
- apportionment
- causal circumstances
- level of disability
- future impairment
- fitness for duty

All of the above are affected by causation.
Treatment, however, would not vary regardless.

Causation

- Diagnosis occurs in context! Causation is about context.
- Common factor among products used at work is exposure to isocyanates (MSDS)
- Circumstances at work:
 - Long hours, works overtime
 - Exposure within breathing zone
 - Spaces with restricted ventilation (not true “confined spaces”)
- Hazard control
 - Process controls (used in industry, not so much in construction)
 - Ventilation (fans, ducts)
 - Personal protective equipment (respirators, skin protection)
 - Training and worker education
- Why him? Sensitization is a *stochastic* phenomenon, like infection.

Causation Analysis (if dispute)

Essentials of Causation

- “Arising out of work”
- Specific, responsible exposure
- Work relationship
- Circumstances of exposure
- Possible interactions
- Interpretation:
 - underlying cause
 - proximate cause
 - aggravation

Epidemiology and causation

- Cannot/should not use epidemiological principles for the individual case:
 - Patients \neq populations
 - Hill criteria do not apply.
 - Epi inferences are post hoc, single cases are Bayesian.
 - Standard of certainty is not the same.
 - WC Acts are clear: individual case evaluations

Causation analysis is often performed by Independent Medical Examiners or AMEs.

Causation triggers decisions!

- Disorders “arising out of work” may be eligible for compensation:
 - Workers’ compensation
 - Medical expenses
 - Sometimes rehabilitation services
 - Income replacement
 - Temporary disability
 - Permanent disability – permanent impairment
- Dispute resolution
 - Workers’ Compensation Appeals Board
- Protection for current and future workers
- Once claim is accepted and patient is “at permanency”, disability evaluation is next step.

Impairment Assessment

Impairment Assessment

- Objectively measured
- Physician providers
 - Often as an IME or AME
 - *AMA Guides to the Evaluation of Permanent Impairment*
- Different systems for:
 - Workers' compensation
 - Social Security Disability Insurance
 - Long-term Disability
- Apportionment

Disability Evaluation

- Extrapolated
- Builds on impairment
 - Actuarial calculations
 - Individual insurers have their own algorithms
- Comes down to a determination on income support.
- Causes of disability can be “apportioned”; injury cannot.

ATS, AMA Impairment Criteria

Rating Class	Impairment, Total Person (%)	FVC % pred*	FEV₁ % pred*	FEV₁/FVC %	D_{LCO} % pred	dV_{O2} (ml O₂/min/kg)
<i>Class 1</i> (All required)	0, none	≥ 80	≥ 80	≥0.70 (AMA and ATS)	≥70 (AMA), ≥80 (ATS)	>25
<i>Class 2</i>	10 - 25	60-79	60-79	0.60-0.74	60-69	20-25
<i>Class 3</i>	26 – 50	51-59	41-59	0.41-0.59	41-59	15-20
<i>Class 4</i>	51 - 100	≤50	≤40	≤0.40	≤40	≤15
Any 1 criterion for 2 - 4	AMA only	Crapo, 1981	Crapo, 1981	ATS only	Crapo, 1981	AMA only

- California allows “expansion” with justification, usually adjustments based on ADL.
- California requires use of the 5th edition, only. (* Adjust predicted values for race.)

Problems for this patient

- System does not cover everything!
- Nature of this patient's disorder suggests future problems:
 - Airways disorder makes fitness to work variable and unpredictable.
 - Interstitial disorder reduces exercise tolerance.
 - Both render patient susceptible to future respiratory problems.
- Future morbidity - prognosis
 - Predictable increase in sickness absence compared to peers
 - Risk of premature permanent total disability
 - Premature mortality on a statistical basis

How do we protecting the “other guys” in the workplace?

- This is a sentinel event!
- Reportable to OSHA/CalOSHA
 - By physician
 - By employer
- If index case in epidemiological study, exposure assessment will be the problem.
- Certainly a statistical data point, BUT:
 - Massive undercounting of occupational disease (~10% completeness)
 - Respiratory disorders poorly classified by Bureau of Labor Statistics

Installing windows
in a new energy-
efficient school in
Pecos TX.
www.pecos.net

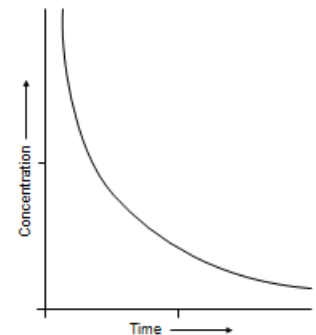
Occupational Health and Safety

- Standards for exposure to isocyanates in the workplace are set by the US Occupational Health and Safety Administration
 - Part of the Department of Labor, which is not a health agency
 - New standards are based on review of scientific lit but many OSHA standards date from before 1970. **Like this one!**
 - Three sets of standards (amended 1983, vacated 1993):
 - General Industry
 - Construction
 - Shipyards

Harmonized in the case of isocyanates, fortunately.
- In theory, based on:
 - Extrapolation from animal testing ($LC_{50} = 14$ ppm, rat)
 - Human studies (epidemiology, rarely clinical)

What is the “OSHA Standard”?

- “Air Contaminants” Table Z1 of 29 CFR 1910
- Standards for isocyanates (TDI and MDI): PEL
 - 8-hour time-weighted average: 0.005 ppm
 - This is an average over a typical work shift: must be adjusted for different duration
 - Based on “Haber’s Law” ($C \times t = k$) and assumption of cumulative effect
 - Ceiling: 0.02 ppm
 - Absolute maximum
- Monitoring (OSHA Method 18)
 - Based on a collector solution in toluene
 - Gas chromatography
 - DL 0.15 ppb (for TDI)



Are your patients protected?

- Not particularly well!
 - Susceptible populations
 - Atopy
 - Preexisting respiratory disease
 - Sensitization
 - Mixtures (assumes additive)
- Standards setting is unresponsive:
 - This standard was adopted in 1971!
 - Revisions in 1989 were vacated by court decision in 1993.
 - No action since then
- Do not assume that < PELs, TLVs, REL are “no effect” levels!
- Industrial hygiene measurements are not always representative.

Other Recommendations are consistent.

- American Conference of Governmental Industrial Hygienists (ACGIH):
 - TLV: 0.005 ppm (TDI, MDI)
 - STEL: 0.02 ppm
- National Institute for Occupational Safety and Health (NIOSH):
 - REL: 0.005 ppm (TDI, MDI)
 - IDLH: 2.5 ppm
- Carcinogen? NIOSH+, IARC±, OSHA, EPA –

Appropriate Protection

Personal Protective Equipment

- For big spaces, spraying insulation
 - Supplied air
- For heavy use, smaller objects
 - Supplied air
 - Painting booth
- Appropriate when applied with a brush, caulking, small quantities.
 - Air purifying
 - Half-face mask, minimum
 - Cartridges rated for “acid gas and organic vapor”, which is yellow

MOLDEX® 8000 Series Half-Mask Respirator
www.labsafety.com

What does his work contribute?

The modern built environment:

- Energy efficient
- Weatherproofed
- Climate controlled
- Small ecological footprint
- Clean and easy to maintain
- He's building our new world.

Case Study



Courtesy of
Building Health Sciences,
(a division of The NMAS
Group), Rockville MD.

Fungi

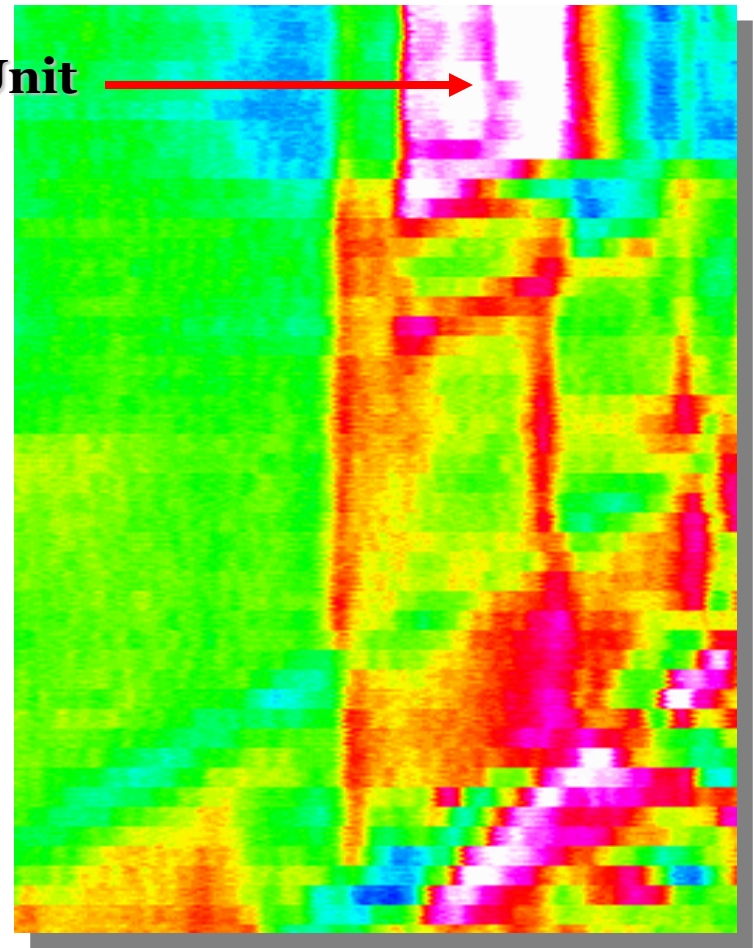


Case Study

Water Intrusion from Window and Entrapment Behind Cladding



Black & White Thermogram



Color Thermogram

Slides of case study courtesy of Don Franklin, CEO, Building Health Sciences

“Big Picture”

Environmental Implications

- Isocyanates are essential products for energy conservation and building design: No substitute.
- LEED Accreditation (Certification)
 - Stands for “Leadership in Energy and Environmental Design”
 - Very popular for new hospitals.
 - Point system is almost entirely about energy efficiency.
- LEED does not have a health component.
 - No points for health measures
 - Occupants may have fewer illnesses.
 - Occupational health issues not considered
- LEED in schools, hospitals, office buildings.

Local Environmental Implications

- No EPA “air toxics” standard for isocyanates.
 - EPA has a benchmark: $RfC = 0.00007 \text{ mg/m}^3 \cong 10^{-5} \text{ ppm}$
 - Is this a discrepancy or an oversight?
 - Answer is in isocyanate chemistry.
- Owners of workplace are subject to several regulations regarding accidental release and community notification:
 - CAA RMP: Threshold quantity 10,000 lbs.
 - CERCLA: “Reportable quantity” of 100 lbs.
 - SARA (community right to know): covered
 - EPCRA (community and emergency response):
 - Public Data Release annually
 - *De minimis* level 0.1% - exempts from reporting

Net effect of these measures has been to involve community residents and disseminate information on local hazards. Is this unequivocally a good thing?

Home and Family Environmental Exposure

- EPA has almost no authority in private homes.
- Local public health agencies rarely intervene in private homes.
- Passive exposure of this worker's children.
 - Carried home on clothing? Highly likely.
 - Standard is that workers should leave their work clothes at workplace to be laundered.
- The rise of Children's Environmental Health has become a driving force:
 - First in environmental health management
 - Now throughout EPA as a foundation for policy
 - Isocyanates a shared risk with housing and schools.

Environmental Offsets

- Energy conservation ↔ Construction risks
- Energy efficiency ↔ Indoor air quality
- Community right to know ↔ Homeland security
- Community autonomy ↔ Public health responsibilities
- Limiting inventory on site ↔ Susceptibility to interruptions

But what about this worker?

- He is likely to have on-going respiratory problems.
- He is likely to have repeated short absences.
- He will have to settle for a job at less pay.
- His family will have less money.
- His job security is threatened.
- His self-esteem may be affected.

Make a big mistake, and you harm
him, his family, his employer,
the community.

Primum non nocere! First do no harm!

This is not them, but it could have been.
www.pencilplace.com

Fitness for Duty (Fitness to Work)

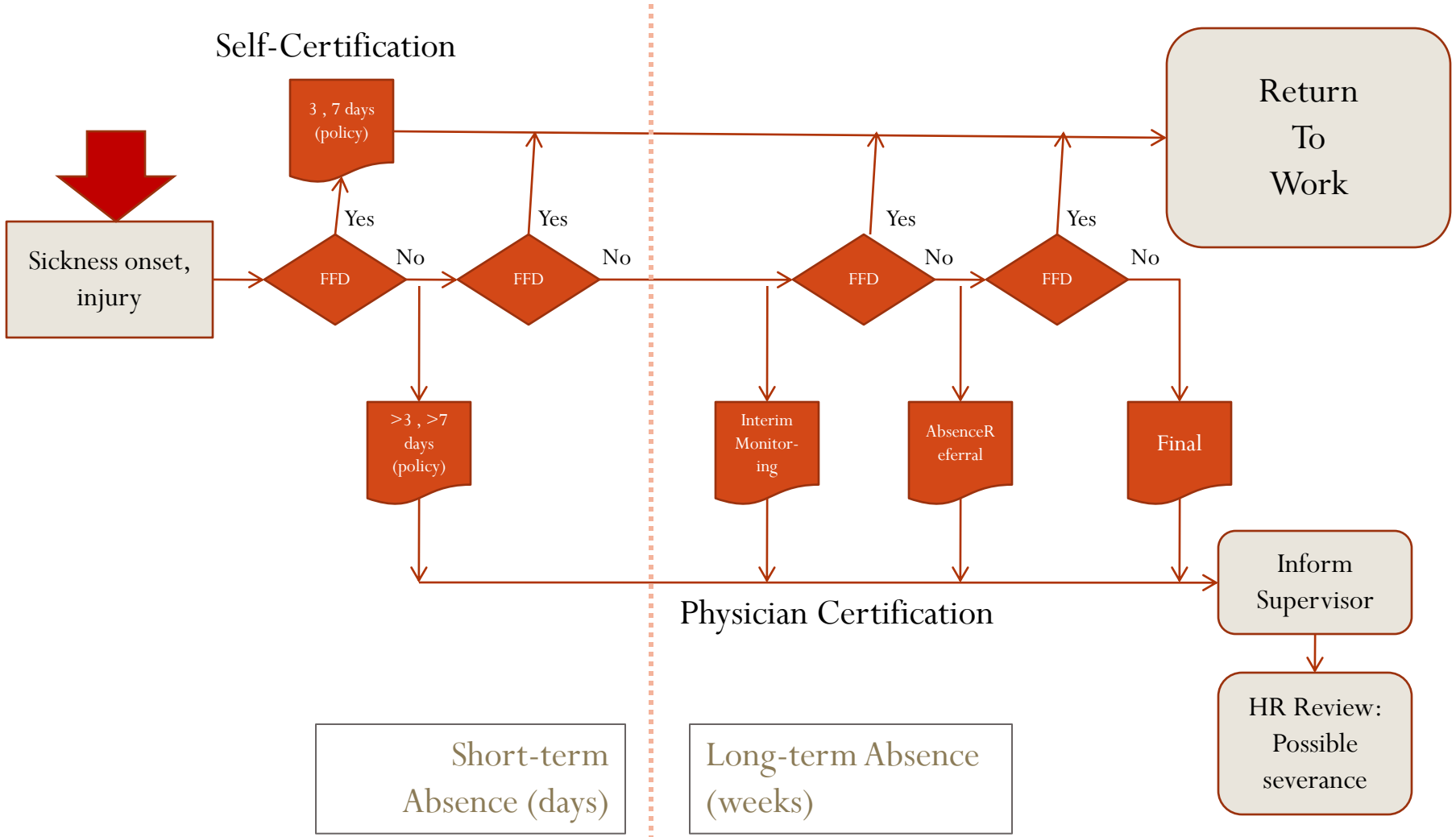
Job Requirements

- Physical requirements
 - Strength
 - Agility
 - Stamina
- Mental requirements
- Conditions of work
 - Presence of sensitizer
 - Other respiratory hazards
- Duration and hours
 - Shiftwork?

Capacity to do the Job

- Functional capacity of worker
 - Not maximal exertion
 - Can worker do the job?
- Americans with Disabilities Act
 - Accommodation required?
 - Preplacement evaluation
- Cannot take prognosis into account

Return to Work After Absence



Tricky transitions

- Return to work (RTW), but not 100% → Many employers *refuse* accommodation (“light duty”)
- Short-term disability (STD) → Long-term disability (LTD)
- Workers’ compensation claim → Permanent partial disability (PPD) + a new job
- LTD or PPD → Retirement
- “Second injury” → Apportioning impairment/disability
- Non-occupational illness → Aggravation, exacerbation

Social function in medicine

Specific Functions

- Sentinel event monitoring
- Causation/causality
 - apportionment
 - causal circumstances
- Current impairment
- Preventing future impairment
- Fitness to work

Institutions

- Workers' compensation
- Occupational health regulation
- Employer responsibility
- (Public health)
- (Human rights)

Social dimension: why accurate diagnosis, causality is important.

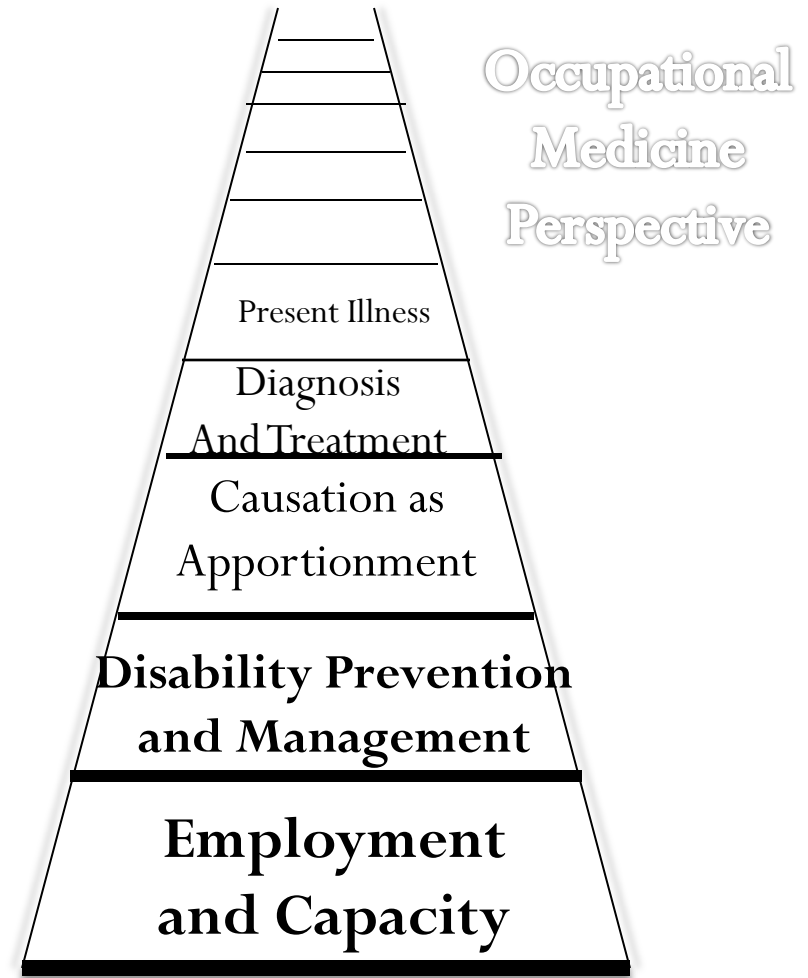
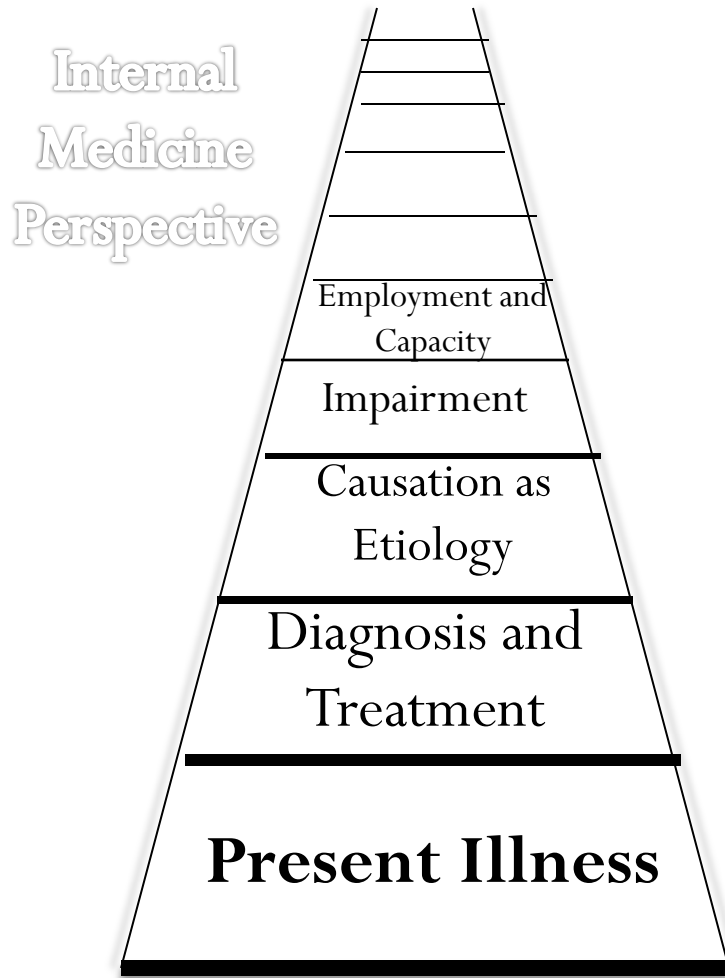
Values

- Equity
- Fairness (Justice)
- Sufficiency
- Transparency
- Sustainability

Means we need to strive for:

- Standardization
- Consistency
- Predictability
- Reliability
- Rapidity
- Validity

Perspectives



Lessons to be Learned

- Occupational medicine is driven by technological change.
- It is quite possible to practice excellent clinical medicine and still ruin your patient's life.
- There is still a role for the “clinical diagnosis”: not everything can be validated by a lab test.
- The physician acts as gatekeeper and is at the center of a social insurance system.
 - It affects patient's lives just as much as clinical treatment.
 - The general healthcare system does not recognize this.
 - Workers' compensation does.