In-Depth Analysis Of Work-Related Fatalities In Taiwan

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Education

- Ph.D. State University of New York at Buffalo, **1990**
  Industrial Engineering Dept major in Human Factors

Experience

- Professor in National Taiwan University of Science & Technology **since 1998**
- President of the Ergonomic Society of Taiwan **2003-2005**

• Research Interest

Accident Analysis

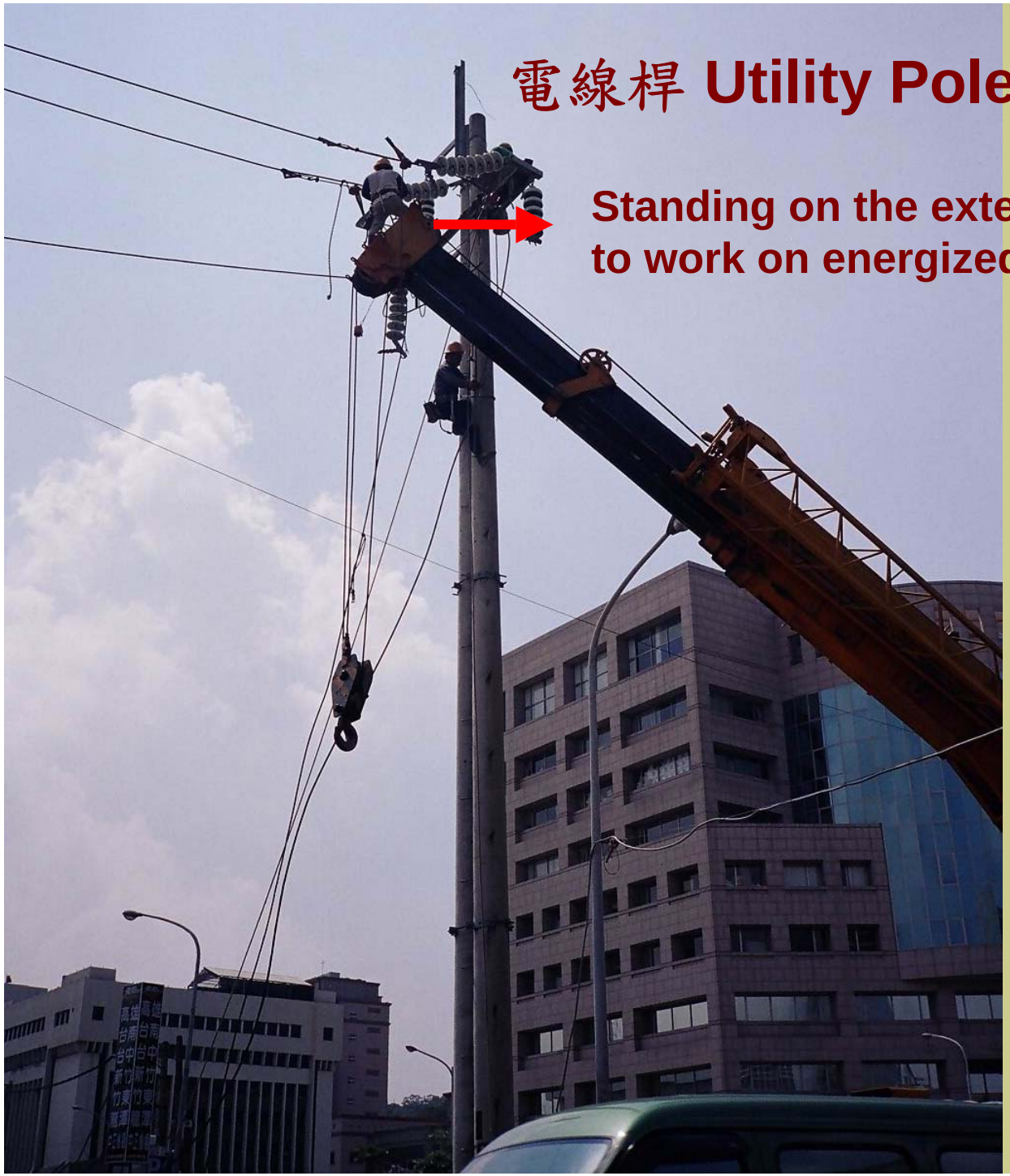
Aging & Disabled Workers

Published a Book

Job Analysis and Job Redesign for Disable Worker

Standing on a steel frame that needs to be cut off by a power tool

電線桿 Utility Pole



Standing on the extended arm of a boom truck to work on energized items


Sitting/walking on bamboo scaffold
without horizontal braces

Scenario analysis
Find patterns in archived data

- **Math is a science of patterns, using math we can examine numeric patterns.**

The Pleasure of Finding Things Out by Richard Feynman.

In Japan, aging workers had more

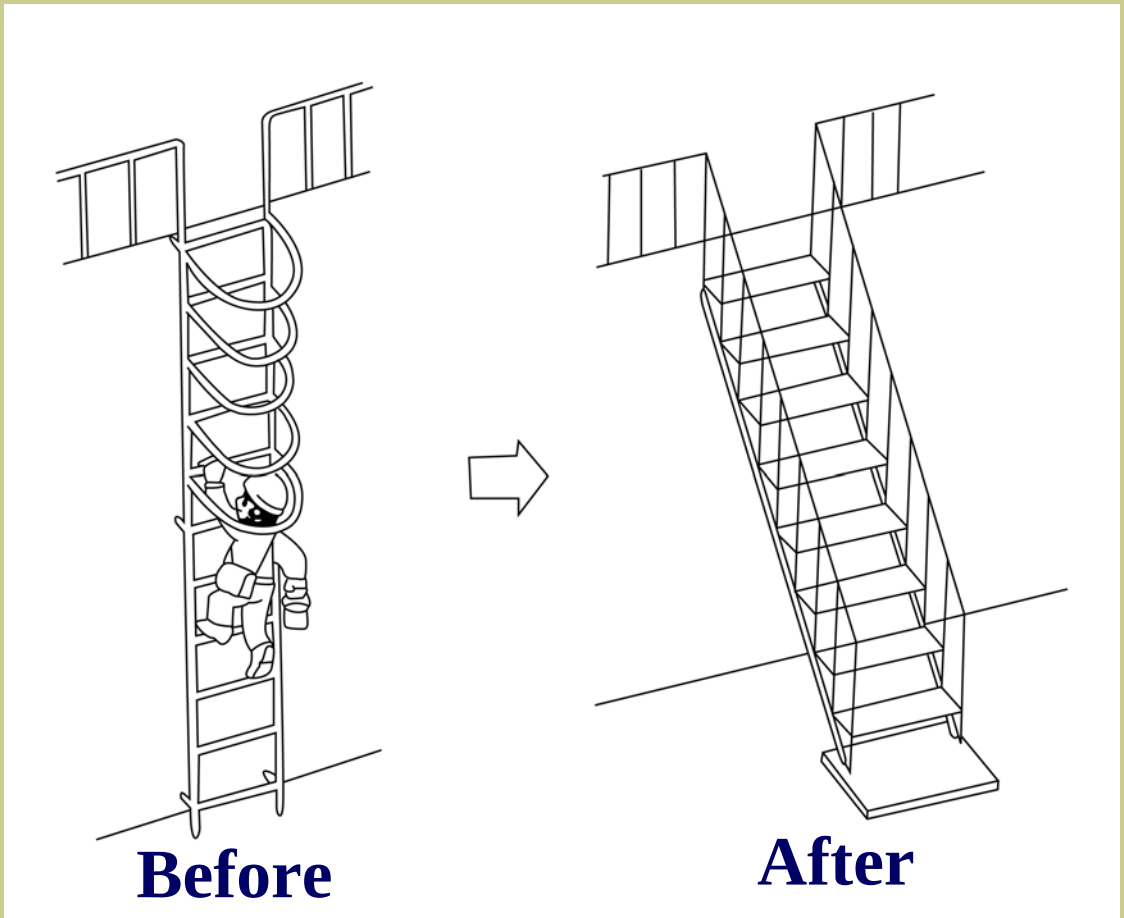
- falling,
- tripping,
- struck by or against,
- overexertion injuries.

Preventive measures were developed to protect aging workers from these occupational injuries.

The Institute of Occupational Safety & Health (IOSH)

Preventing Occupational Injury For Aging Workers

1994-1995



Fatality Report

一、行業種類：電路及管道工程業(Industry)
二、災害類型：感電(Accident type)
三、媒 介 物：電力設備 (Source of injury)
四、罹災情形：死亡男一人 (Gender)，二十一歲 (Age)，工作經歷：不詳(Experience)

五、災害發生經過：(How it happen)

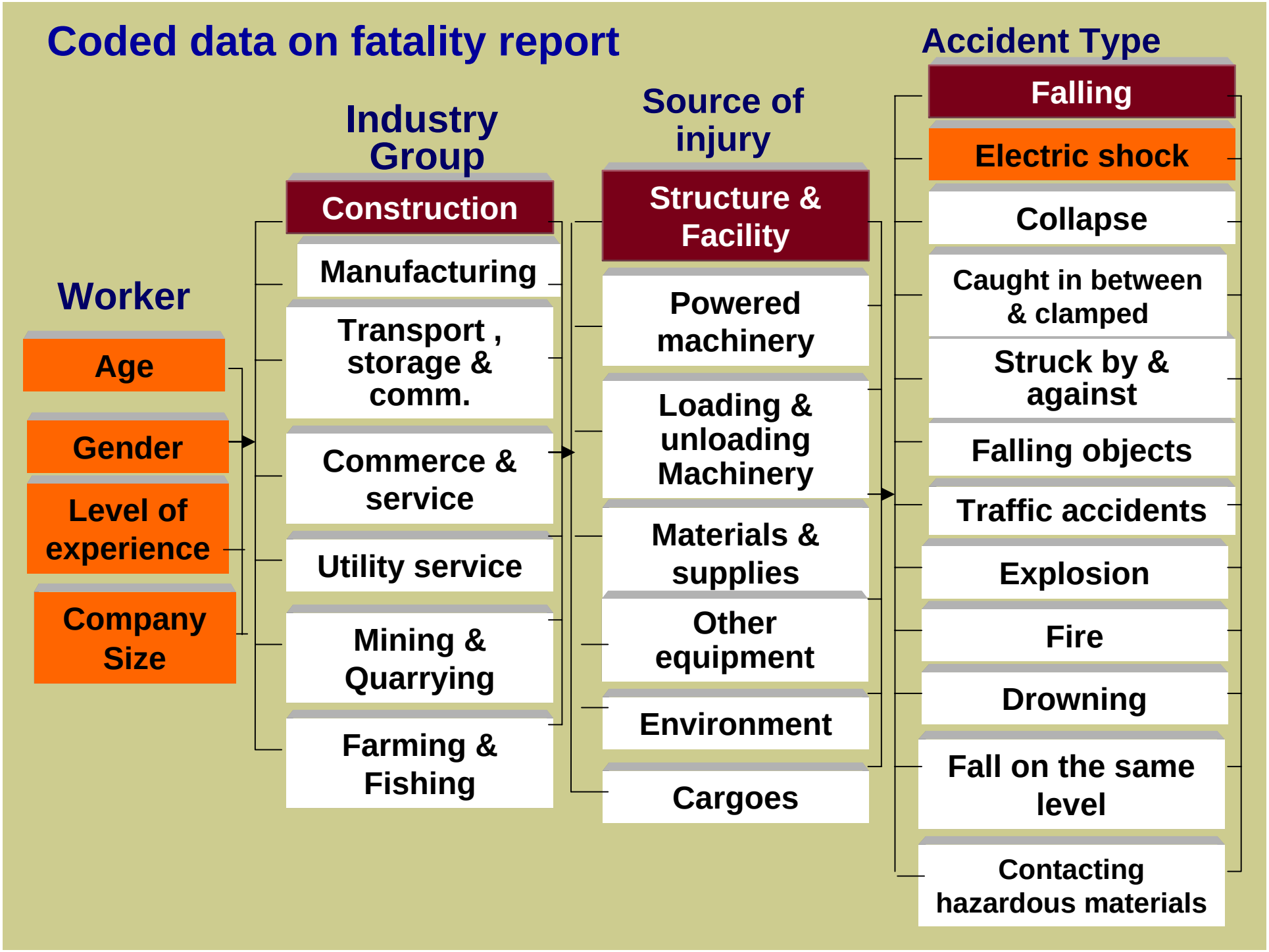
台北縣瑞芳鎮某耐火公司將廠內供電系統主配電工程交付某水電工程公司承攬，85年1月27日下午4時，水電工甲在配電室樓下泵浦間整理工具，要將工具拿到配電室放置時，聽到配電室傳出叫聲，由樓梯走上配電室看到電工乙倒在地上，LBS4配電盤的門開著，將罹災者送醫急救無效死亡。廠區二樓配電室LBS4配電盤內電壓為11.4KV，罹災者工作內容為電纜線頭端子之加工，加工完成後將其放置於配電室門邊，災害檢查時造成感電LBS4配電盤內自動照明燈仍亮著，該照明燈於鐵門關閉時應自動熄滅，故顯有故障，LBS4配電盤門邊有一處明顯電擊痕跡。

六、災害發生原因(Why it happen)

依據地檢署相驗書記載：罹災者死亡原因為意外電擊死亡。
罹災者將加工完成之電纜線搬至配電室置放後，可能為勘查日後停電作業位置而開啟LBS4配電盤之鐵門察看後，關閉鐵門卻發現自動開關照明燈不會關閉，再度開啟鐵門欲排除故障，於調整照明燈關開時，右手扶鐵門、左手觸及高壓匯流排遭電擊死亡。罹災者在接近高壓電場所從事修理，未於該電路裝置絕緣防護裝備。未設置勞工安全衛生主管，實施自動檢查。
對勞工未實施安全衛生訓練，勞工安全衛生知識不足。未訂定安全衛生工作守則，供勞工遵循。

七、防止災害對策：(Prevention measure)

為防止類似災害發生，有採取下列措施之必要。
對於勞工在接近高壓電場所從事檢查、修理作業時，應於該電路裝置絕緣防護裝備。
應於工地設置安全衛生業務主管，對使用之設備及其作業實施自動檢查。對勞工實施從事工作必要之安全衛生教育、訓練，並將本案列入訓練教材，提高勞工安全衛生知識，防止類似災害發生。


Coded data on fatality report
Worker
Age
Gender
Level of experience
Company Size
Industry Group
Construction
Manufacturing
Transport , storage & comm.
Commerce & service
Utility service
Mining & Quarrying
Farming & Fishing
Source of injury
Structure & Facility
Powered machinery
Loading & unloading Machinery
Materials & supplies
Other equipment
Environment
Cargoes
Accident Type
Falling
Electric shock
Collapse
Caught in between & clamped
Struck by & against
Falling objects
Traffic accidents
Explosion
Fire
Drowning
Fall on the same level
Contacting hazardous materials

Derive accident scenarios in terms of

Scenario	Contributing factors
Who is boss ? **Who is worker ?**	Company size, Industry type Age, Gender, Experience, Fatigue, Inadequate Training,
What happened ?	Performing task Accident type
Using what type ?	Source of injury, Tool/Equipment
When ?	Time/Climate
Where ?	Falling site
Why ?	Unsafe act ? Unsafe equipment ? Unsafe environment ?

How to prevent ?

Methodology I: analysis of coded data

Read report→*Coding scheme*→Coding→Analysis

1. **Identify essential data elements (contributing factors) within coded *and narrative data* to characterize a series of accident;**
2. *2. Reconstruct the injury events using a template to describe the sequence of events in a standardized way;*
3. *Develop taxonomies of the sequences according to essential data elements (Contributing factors)*
4. *Identify hazard scenarios (common injury mechanisms) for developing interventions.*

Lincoln, A. E. Sorock, G. S., Courtney, T. K., Wellman, H. M., Smith, G. S., Amoroso, P.J. (2004) Using narrative text and coded data to develop hazard scenarios for occupational injury interventions. *Injury Prevention*. 10, 249-254.

Relationships between age & occupational injury

- **(↗)：The rising trend** was caused by a functional decline with age (Laflamme & Menckel, 1995). **Continuous rapid information processing & strenuous physical activity (Warr, 1994).**
- **(↘)：**Jobs **required experience & refined skills, and compensatory mechanisms** serve to reduce the physical & cognitive deficiencies , or progressive selection.
- **U：**Initially, age & experience were beneficial, but became less of an advantage after a certain age (Laflamme & Menckel, 1995)
- **Inverted U(∩)：**Workers perform riskier jobs at their prime age.
- **W：**An initial decline (experience), followed by a rise (functional decline with age), & another decline (compensation mechanisms) (Schmidt et al.,1985).

The relationship between age and fatality rate differed depending upon the accident type

- Fatality rate has **a rising trend (↗) with age** for most accident types.
- Fatality rate of **electric shock** declined (↘) with age.

Accident type	All	Falls	Collapse	**Electric shock**	Struck by	Falling objects	Explode	Drown	Slipping tripping
Age	↗	↗	↗	↘	↗	↗	↗	↗	↗
<24	4.1	1.4	0.3	**1.0**	0.2	0.1	0.0	0.1	0.0
25-34	4.1	1.3	0.5	**1.0**	0.2	0.2	0.1	0.1	0.1
35-44	4.4	1.9	0.4	**0.5**	0.3	0.2	0.1	0.1	0.1
45-54	7.4	3.2	0.9	**0.4**	0.5	0.3	0.2	0.2	0.3
>55	8.8	4.1	1.1	**0.4**	0.9	0.5	0.3	0.2	0.3

Chi, Chia-Fen & Wu, Meng-Lin (1997) Fatal occupational injuries in Taiwan-relationship between fatality rate and age. *Safety Science*, 27, 1-17.

Archived data can be as informative.

Human Factors In Consumer Product Accident Investigation

Colin Drury & Michael Brill (1983) *Human Factors*.

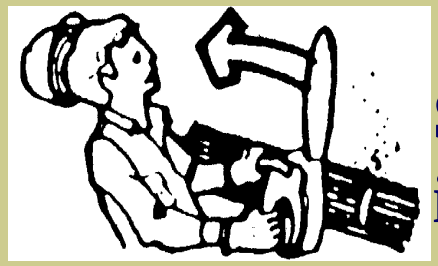
Collect and analyze epidemiological data from hospital ERs to derive accident scenarios in terms of

- **Victims (Actors),**
- **Products (Props),**
- **Environment (Scene),**
- **Task (Action)**

II Scenario Analysis

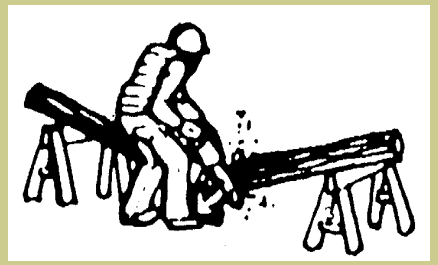
Find patterns using narrative data

Kickback



Lose control of Saw through inattention

Lose arm or hand control of saw



Lose full body balance

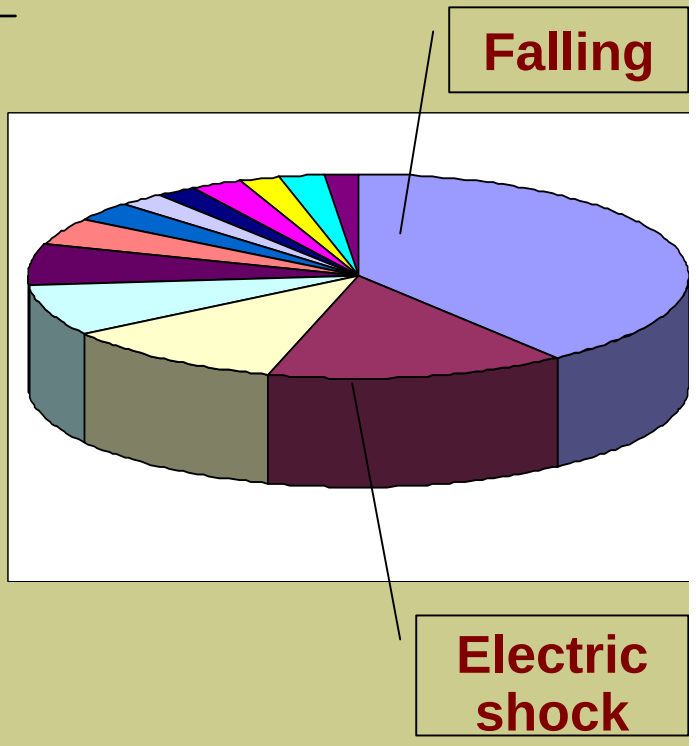
Scenarios are considered useful if

A maximum of 6 scenarios accounts for > 90% of accidents

Each suggests at least 1 feasible & effective intervention

Fatal occupational injury in Taiwan (1989, 1990, 1992)

Accident pattern	Freq	%
Falling	**488**	**39.7**
Electric shock	**180**	**14.6**
Collapse	139	11.3
Caught in between, & clamped	**97**	**7.9**
Struck by and against	79	6.4
Falling object	54	4.4
Traffic accidents	38	3.1
Explosion	28	2.3
Fire	25	2.0
Drowning	30	2.4
Fall on the same level	25	2.0
Contact hazards & extreme temp	27	2.2
Non-classified/unknown	20	1.6
Total	1230	



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Methodology

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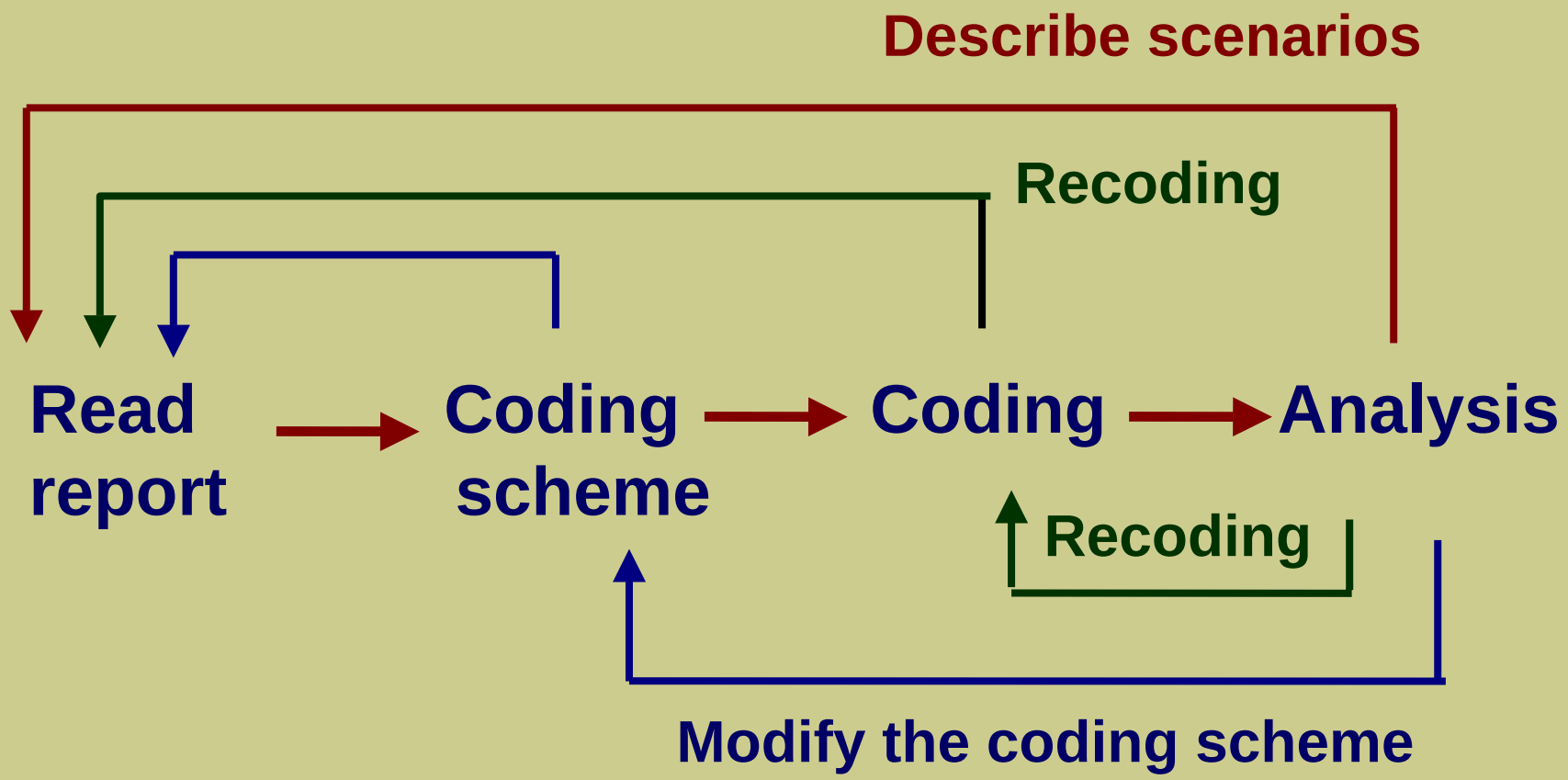
Iterative process



Classification Schemes – Falling site

According to Bureau of Labor, Bureau of Labor Statistics (2003)

1. Fall from stairs or steps,
2. Fall through existing floor opening,
3. Fall from ladder,
4. Fall through roof surface (including existing roof opening & skylight),
5. Fall from roof edge,
6. Fall from scaffold and staging,
7. Fall from building girders or other structural steel,
8. Fall from vehicle and mobile equipment,
9. Jump to lower level,
10. Fall through existing roof opening,
11. Fall from floor, dock, or ground level, and
12. Other non-classified fall to lower level events.

Factor	Item	Freq	%
Falling site	Fall from scaffold, staging	189	29.5
	Fall through existing floor opening	128	20.0
	Fall from building girders or other structural steel	70	10.9
	Fall from roof edge	65	10.1
	Fall through roof surface	44	6.9
	Fall from ladder	26	4.1
	Fall from vehicle and mobile equipment	20	3.1
	Fall down stairs or steps	11	1.7
	Jump to lower level	2	0.3
	Fall through existing roof opening	2	0.3
	Fall from floor, dock, or ground level,nec.	51	8.0
	Fall to lower level, n.e.c.	33	5.1

Classification Schemes -- Causes of falling

Following Drury & Brill's (1983) scenario analysis

Individual

– bodily actions (e.g. climbing, walking, and leaning against),
– distraction,
– insufficient capacities,
– improper use of PPE.

Task (confused with poor work practice)

– overexertion and unusual control,
– poor work practices, and
– removal of protection measures.

Equipment

– mechanical failure,
– unsafe ladder and tools, or
– being pulled down

Management and environment

– unguarded openings,
– lack of complying scaffolds,
– unauthorized access to hazard areas,
– contact with falling object, and
– harmful substances.

Phi coefficients between cause of fall and accident event.

Site / Causes	From scaffold, staging	Through floor opening	From building girders	From roof edge	Through roof surface	From ladder
Lack of complying scaffold	**82 0.267^{++}**	6 -0.246**	7 -0.128**	6 -0.129**	43 0.454^{++}	4 -0.050
Unguarded opening	6 -0.240**	**53 0.337^{++}**	13 0.017	10 -0.012	0 -0.124**	0 -0.094^{a,*}
Bodily action	**26 0.083^{+}**	4 -0.117**	14 0.119^{++}	11 0.079^{+}	0 -0.092^{a,*}	1 -0.043^{a}
Poor work practices	15 0.022	6 -0.048	5 0.001	4 -0.012^{a}	0 -0.076^{a,*}	0 –0.058^{a}
Being pull down	10 -0.027	9 0.016	1 -0.071^{a}	11 0.150$^{a,++}$	0 -0.071^{a}	2 0.012^{a}
Inappropriate protection	3 -0.116**	**23 0.272^{++}**	3 -0.021^{a}	1 -0.061^{a}	0 -0.067^{a}	1 –0.016^{a}
Improper use of PPE	4 -0.056	1 -0.079^{a}	4 -0.012^{a}	1 -0.039^{a}	1 -0.021^{a}	1 0.002^{a}
Removal of protection measure	1 -0.104*	**11 0.147$^{a,++}$**	11 0.150$^{a,++}$	0 -0.064^{a}	0 -0.052^{a}	2 0.050^{a}
Overexertion unusual control	6 0.025^{a}	2 -0.033^{a}	1 -0.061^{a}	1 -0.022^{a}	0 -0.045^{a}	4 0.169$^{a,++}$

Effective countermeasures were developed based on the association between falling site and cause of fall.

Falling site	Cause of fall	Freq

Fall Protection Guideline (Manitoba Labor & Immigration Division, 2003)

- **Primary (active)**: **prevent** falls to a lower level **from occurring**
- **Secondary (passive)**: **inhibit or minimize injury** after an already initiated fall

Primary					**Secondary**		
Fixed barriers		**Surface opening protection**		**Strong roofing material**	**Travel restraint systems**	**Fall arrest systems**	**Fall containment systems**
Guardrails Handrails,	Warning barrier sign & tape	Floor coverings	Crawling boards, planks		Safety belt	Safety harness	Safety nets

Accident event	Cause of fall	Freq	Primary				Secondary		
			Fixed barriers		Surface opening protection		Travel restraint system	Fall arrest system	Fall containment systems
			Guardrails Handrails	Warning barrier, sign & tape	Floor coverings	Crawling boards planks	Safety belt	Safety harness	Safety nets
From scaffold, staging	Lack of complying scaffold	82	X	X				X	X
	Bodily reaction	26							
From building girders or other structural steel	Bodily reaction	14						X	X
	Improper use of PPE	10							

Fatal Falls In Construction Industry

Chi, Chia-Fen, Chang, Tin-Chang and Hsin-I Ting (2005)

Accident Patterns and Prevention Measures for Fatal Occupational Falls in the Construction Industry,

***Applied Ergonomics*. 36, 391-400**

Fatal Electrocutions In Construction Industry

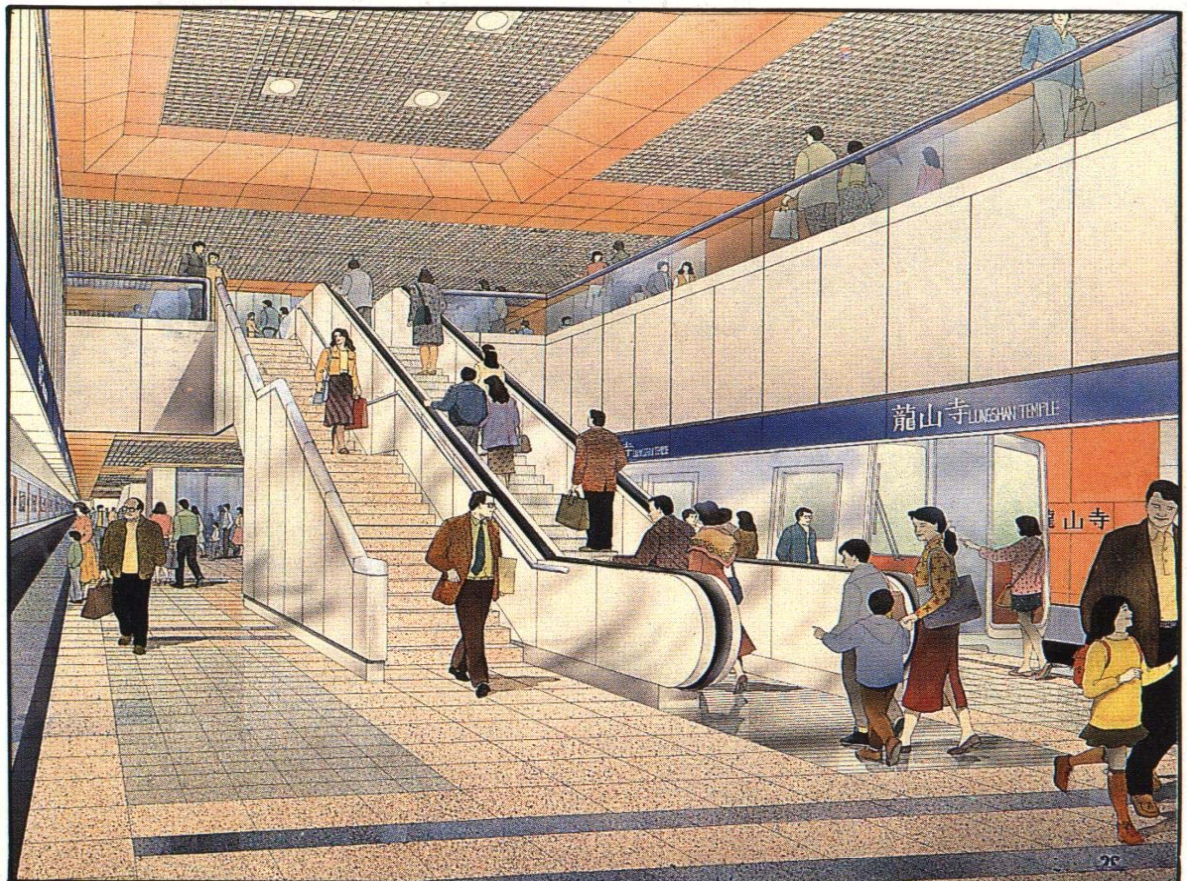
Chi, C. F., Chong-Cheng Yang and Zheng-Lun Chen(2007) In-Depth Accident Analysis of Electrical Fatalities in the Construction Industry.

***International Journal of Industrial Ergonomics*, (In Press).**

In-Depth Investigation Of Escalator Riding Incidents In Heavy Capacity MRT Stations

Chi, Chia-Fen, Chang ,Tin-Chang & Tsou, Chi-Lin (2006)
***Accident Analysis & Prevention*, 38 (4), 662-670.**

Adopt Drury & Brill (1983) model to analyze escalator-riding accidents in terms of victims, task, product and environment.



The causal analysis of requested alterations for pressure garments

Journal of Burn Care and Research **(Accepted)**

Classify the Causes of required alterations according to a hierarchical coding scheme: poor fit, discomfort, component part, fabric and sewing, and cosmetics to identify systematic problems for each garment type.