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Chemical risk in academic research: from raising cultural awareness to providing innovative solutions.

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Academic research: an emerging population & scenario

- More than 10 M workers in the academic sector
- STEM / non-STEM
- Chemical hazards in chemical research
- Chemical hazards in NON chemical research

ACS CHEMICAL HEALTH & SAFETY

pubs.acs.org/acschas Editorial

A Call for Papers "Chemical Safety in Universities: Legally Enforced vs Culturally Embraced"

Cite This: *ACS Chem. Health Saf.* 2025, 32, 1−2 Read Online

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How to define / quantify the working population

Crucial to assessing the size of the problem

- ➢ **Who is an academic worker?**
- ➢ **The trainee – worker conundrum**
- ➢ **The employee – entrepreneur conundrum**
- ➢ **The STEM – non-STEM inter-weaving**
- ➢ **Non-profit – profit institutions**
- ➢ **Beyond the office-laboratory divide**

1-10 million worldwide (?)

Depending on

- **Estimations**
- **Definition**
- **Data sources**

In the lecture hall:
An academic employee

In the research lab:
An academic PI
An entrepreneur

In the lecture hall:
A student
A TA

Technical staff

In the research lab:
A trainee
A worker

Lifelong post-docs

Start-uppers

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Four complementary case histories … lesson learnt

Young unattended lab hand burnt at the stake

- ➢ t-BuLi is pyrophoric: it ignites spontaneously in air.
- ➢ She picked up a plastic syringe and began drawing up 54 millilitre quantities.
- ➢ Her synthetic sweatshirt burned away, she had not been wearing a lab coat. She was never properly trained or even issued a lab coat. She died out of the received burns.
- ➢ The lab had been cited for safety problems but given an extension.
- ➢ **First criminal prosecution of an American academic for a lab accident**

PLAYING WITH FIRE: HOW STAGED EVENTS CAN ENHANCE LAB SAFETY

Simulated laboratory accidents train students to manage stress, identify hazards and respond to real emergencies. By Myriam Vidal Valero

Training is not optional

- ➢ **Chemical operations are often hazardous**
- ➢ **Is the procedure worthwhile?**
- ➢ **Quantity matters in scaling-up operations**
- ➢ **No laboratory work performed without wearing the full specific laboratory attire**
- ➢ **No hazardous work performed in isolation – without surveillance**

- ➢ **Duty-of-care from laboratory heads**
- ➢ **Safety training to all laboratory attendants**
- ➢ **Manual training on hazardous chemical operations**
- ➢ **appropriate clothing in the laboratory**
- ➢ **reciprocal assistance during hazardous operations**

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Four complementary case histories ... lesson learnt

Chemical death of an academic toxicologist

- An internationally known research chemist died of poisoning from a few drops of a potent neurotoxin she spilled on her lab glove 10 months before. She was 48.
- *"She was taking what any of us would have considered prudent and reasonable precautions"*
- hood to protect herself from fumes, face shield and latex gloves
- *"I don't think any of us recognized that the compound was so penetrating"*
- She asked her case to be widely known


NEWS · CHEMISTRY
Mercury Poisoning Kills Lab Chemist
In a tragic end to a story that began last summer, an internationally known research chemist at Dartmouth College, Karen Wetterhahn, died on Sunday of poisoning from a drops of a potent neurotoxin she spilled on her lab glove 10 months ago. She was 48.

Post-hoc glove permeation study

Glove material	Thickness in mil	Breakthrough time
Nitrile	8	0.25 Minutes
Neoprene	31	<10 Minutes
Butyl	13	<15 Minutes
Viton	11	<15 Minutes
Silver Shield	5	>240 Minutes
Silver Shield & neoprene pair	27	>240 Minutes

Appl Occ Env Hyg, 16:2, 233-236, DOI: 10.1080/104732201460389

- **Manipulation of toxics should be kept at minimum necessary**
- **finding alternatives wherever possible**
- **safe procedures and reciprocal assistance during hazardous operations**

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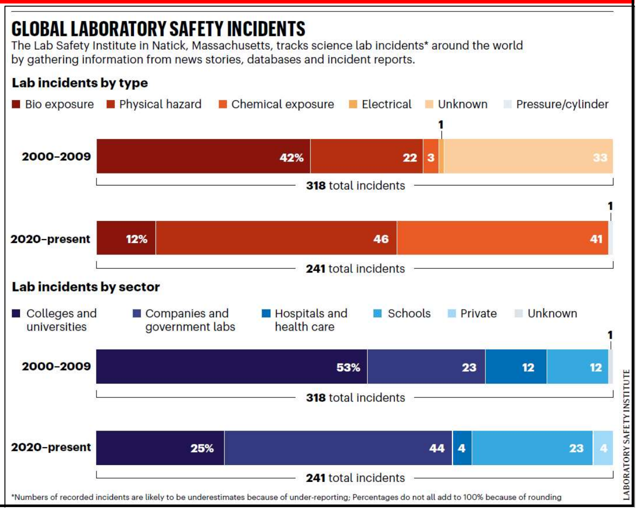
Explosion and fire accidents, acute poisonings are the (however tragic) «folklore» face of chemical laboratory hazards

- **Serious accidents need the intervention of fire engineers and ER teams**
- **«near miss» events go mostly unreported**
- **What about**
  - **Chronic exposure?**
  - **Delayed effects?**



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Four complementary case histories … lesson learnt

Years of unregulated lab waste dumping

- A cluster of cancer cases in a pharmaceutical chemistry university department.
- Only after whistleblowing a criminal case was opened.
- Documents and witness confirmed long-term careless sink disposal of laboratory waste
- Prosecution delay led to abandonement for «prescription» of likely occurred offence to environmental law.
- No prosecution was started for the cancer deaths.

10 cancer Death cases by 2010

By type	n
Lung	3
Colon	2
Brain	1
Thyroid	1
Stroke	1
Dil Card	1

By job	N
Professors	1
Researchers	6
Lab staff	1
Students	1

26 Disease & cancer cases by 2010

Thyroid	9
Undescribed	3
Hodgkin	3
Mal. Semin.	2
Breast	2
Lung	1
Leuk HC	1
Heart dis	1

By job	N
Professors	1
Researchers	8
Lab staff	6
Admin staff	1
Students	7

- The point is not suing responsibility
- Is preventing pollution disease and death
- Waste management in chemical laboratories is a big producer of toxicological issues
- Duty-of-care towards laboratory workers

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Four complementary case histories … lesson learnt

Unprecedented chemical – unexpected hazard

- An academic research chemist synthesized milligram amount of unique compounds for spectroscopic measurement.
- One accidental over-exposure episode led to ER access for dyspnea.
- Diagnostics highlighted extensive lung fibrosis, likely from past cumulative events.
- The chemist alerted peers in an open letter in the national chemists' magazine .

La Chimica e l'Industria (Milano) 86:04, Maggio 2005, p. 99

- Obtaining preventive information on possible toxicity may not be feasible for new compound classes
- Exploiting analogies needs strong interdisciplinary cooperation
- IA-based for preliminary toxicology assessment is *NOW* not beyond possibility

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Chemical risk assessment models for chemical plants

Optimized for
- Highly repetitive tasks
- Huge-large amounts of materials
- A limited number of chemicals at time
- Chemicals with sufficiently well characterized properties
- Limited concurrent activities (plant - lab – office)

Totally inadequate for
- Non-repetitive tasks
- Tiny amounts of materials
- Several different chemicals at time
- Chemicals with poorly characterized properties
- Multiple activities concurrent (lab – office – lecture room)

Alternatives (if any) ...

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Chemical risk assessment models for research labs

Alternatives

Scenario-based
Preventive – retrospective

Optimized for
- Small-Medium Enterprises
- Repair shops
- Craft workers – artists
- Agriculture
- Chemicals in non-chemical environment

Alternatives

Manipulation of anticancer and toxic drugs in hospital pharmacies
- Non-repetitive tasks
- Small quantities of drugs
- Several different drugs at time
- Ready-to-use solutions
- Preservation of sterility
- Chain-of-reference

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Chemical risk assessment models for research labs

Modelling for planning & prevention

- Quantity
- Properties (including hazards)
- Mode of use
- Containment & prevention
- Operator distance from source
- Duration of exposure
- Continuous / intermittent
- Respiratory exposure
- Skin exposure

Measuring for checking & improving

- At workplace level
  - «industrial hygiene» scheme
  - TLV-TWA – TLV-STEL – TLV-C
  - «continuous» monitoring of priority tracers
  - Surface sampling / dust in HVAC
- At worker level
  - Wrist-band passive monitor
  - Biological monitoring / dose & effect (?)

Critical application

Exposure assessment by modelling

Exposure as fraction of OEL	Exposure Code	Measures
0 – 10%	A	Keep current safe operating conditions
10 – 25%	B	Monitor & register changes with previous similar activities
25 – 50%	C	Check major changes that could raise chance of loss of control
50 - 99%	D	Critical operating conditions to be re-evaluated ASAP
> 100%	E	Suspend immediately & activate the alert chain

Exposure assessment by measurement

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The lab notebook as the chief resource

The main lesson a lab trainee receives: keep lab notes

- ➢ Permanent recording for research ethics
- ➢ Reference to individual («*whodunit*»)
- ➢ All operations recorded / redundancy
- ➢ Nature of Chemicals (purchased / original)
- ➢ Quantity / Operations
- ➢ Obtained products /characterization
- ➢ Reference to lab position
- ➢ Tracing dissemination to sources
- ➢ Quantitative assessment of dispersion
- ➢ Objective assessment of prevention efficacy

Company Name, Inc. **Standard Operating Procedure**

Title: Laboratory Notebook Issuance		Procedure Number: QASOP-xxx	Page Number: Page 1 of 3
Function: Quality Assurance		Implementation Date:	Revision Number: 01
Author: Name, Function Signature Date		Approved By: Name, Function Signature Date	
Approved By: Name, Function Signature Date		Approved By: Name, Function Signature Date	

1.0 PURPOSE

This procedure describes the issuance and retention requirements as well as the identification numbering system for laboratory notebooks at Company Name.

2.0 SCOPE

This procedure applies to all laboratory notebooks at Company Name.

3.0 DEFINITIONS

Documentation Administration – QA system designed to process, track, distribute, and file copies of controlled documents, including laboratory notebooks.

Laboratory Notebook (Lab-book) – Bound, legal documents in which are recorded scientific data, protocols, observations, schematics, ideas, and other information that is considered part of the company's research and development operations and intellectual property.

4.0 ASSOCIATED DOCUMENTS/REFERENCES

- QAPOL-xxx – Documentation Policy

5.0 MATERIALS/EQUIPMENT

- Laboratory notebooks (various models as appropriate)

6.0 SAFETY

There are no safety issues relevant to this document.

7.0 RESPONSIBILITIES

7.1 Quality Assurance is responsible for maintaining a record of all laboratory notebooks.

7.1.1 The records will track a unique identifying number for each lab-book.
7.1.2 The records will track who lab-books are issued to.
7.1.3 The records will track the subject/title of each notebook.

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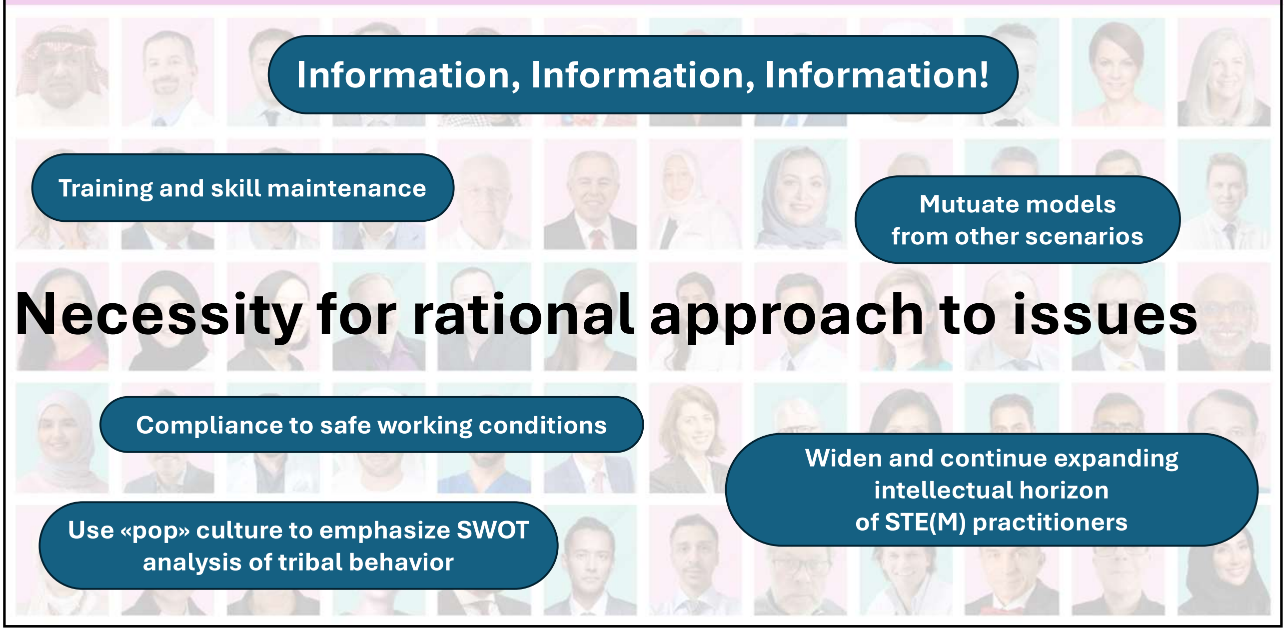
Conclusions, if any (?)



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Chemical risk in academic research: from raising cultural awareness to providing innovative solutions.

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The size of the academic workforce in the STEM has progressively increased and operations involving the use of chemicals have expanded beyond the traditional precincts of chemical, natural sciences and medical research. In addition, operations as conducted in the frame of research do not lend well to chemical risk assessment along the established pathways of industrial hygiene and toxicology. Among the main differences are the general novelty of used substances, for which physico-chemical, technological and biological properties are the very object of study; the limited adequacy of the exposure scenario, essentially based on inhalation of volatiles for which agreed exposure limits are often available; the generally very small amounts of substances handled through multiple manual steps. This unusual scenario is the source of missed, often unreported, accidents, of serious or deadly consequences, of a poor awareness of occupational risk in academic research and of a consequent lack of a sound cultural, scientific and technical base for prevention.

To approach this topic, we examine a few case histories where limited awareness of chemical hazards led to dire consequences for research workers. We will trace analogies and differences among the discussed cases, pointing at causal factors that span from gross violation of well-known safe behaviour [1,2] to accidents caused by insufficient operator protection from very toxic substances [3] to perceivably cautious handling of new substances of an unknown and unforeseen toxicity [4].

To overcome the lack of suitable scientific and technical base for prevention, we refer to the analogy with tackling the occupational risk of handling antineoplastic drugs in hospital departments and pharmacies, awareness of which started in the 1980s and led to successful prevention by a combination of investigation methods and technical interventions. A major advance in exposure assessment derived from surface sampling of drug deposition and systematic analysis of manual working steps and protection devices [5]. This analogy may lead to introducing improved manipulation techniques for chemicals for which traditional approaches may overlook the exposure pathways.

The characterization of the hazard of novel substances may be limited and deemed unnecessary, since most products will not have further application and diffusion beyond one laboratory and research project. Perspectives for preliminary hazard characterization may derive from advanced, AI-based, computational methods [6].

Scientific and technical advances in hazard and risk characterization, however, will hardly suffice in mitigating chemical exposure-derived occupational risk in academia. Cultural awareness should be expanded both from the intellectual world of life sciences to that of academic chemical practitioners and from the chemical professions towards the many others that use chemical substances and operations with insufficient consciousness of hazard and potential risk.

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