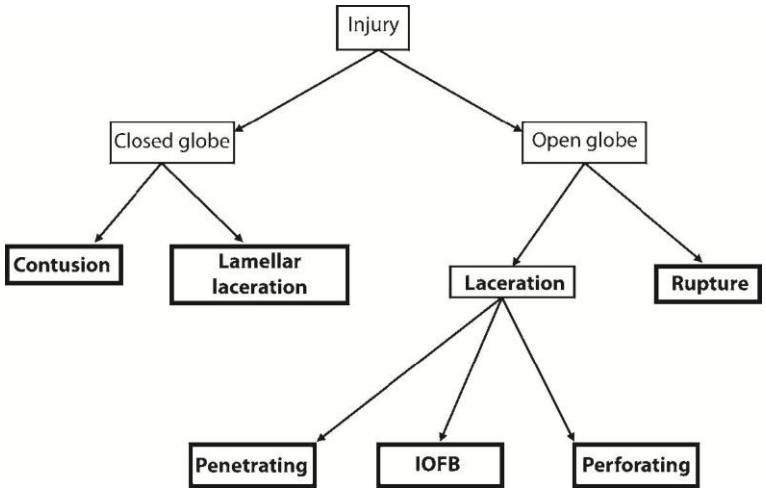
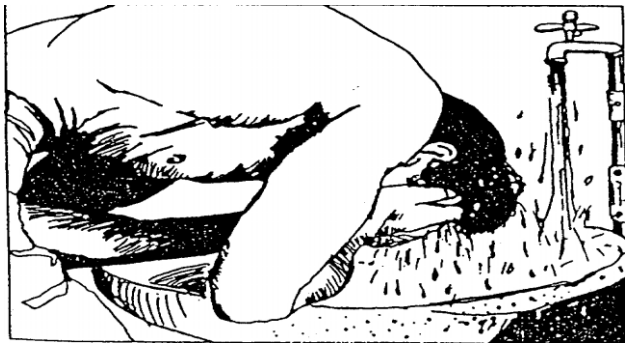
Hazards for visual and ocular injuries





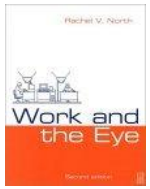


Outline

- Occurrence of eye injuries and their prevention
- Mechanical ocular injuries
  - BETT chart vs. Ocular Trauma Score
  - Ocular traumatology: visual and ocular hazards
- Non-mechanical ocular injuries
  - Ocular toxicology: visual and ocular hazards
- Design of eye protection equipment
  - Standards related to eye protection
- Discussion
  - Supplementary reading and learning
  - Mandatory activity no. 4

Bibliography & Links

- **Basic:**



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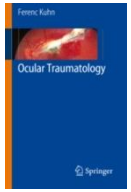

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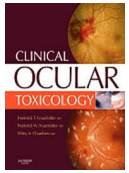


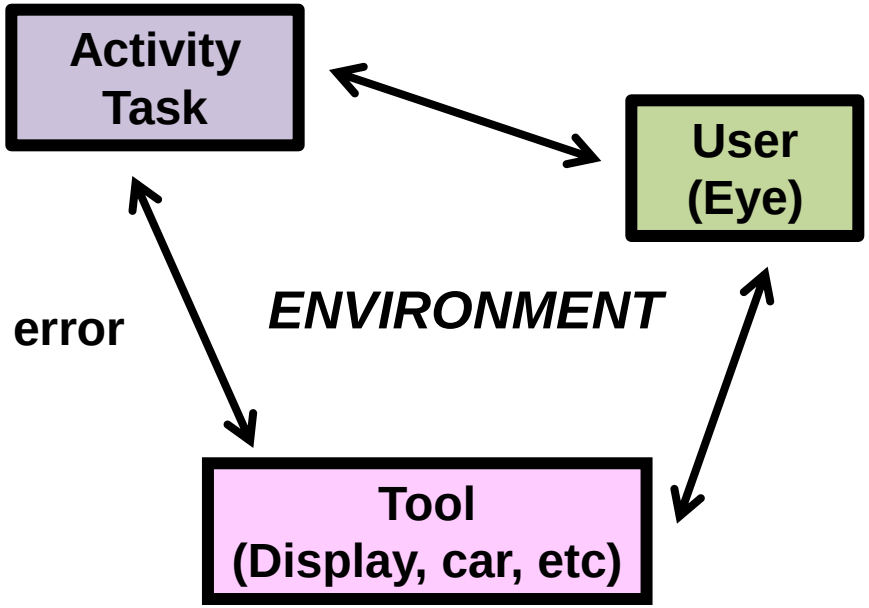
- **FRAUNFELDER, F.T., FRAUNFELDER, F.W., CHAMBERS, W.A.: *Clinical ocular toxicology*. Philadelphia: Saunders, Elsevier, 2008.**

Bibliography & Links

- **Complementary:**
  - **AOO website:** American Optometric Association
  - **INSHT website:** INSTITUTO NACIONAL DE SEGURIDAD E HIGIENE EN EL TRABAJO
  - Agencia Europea para la Seguridad y la Salud en el Trabajo
  - **OSHA website:** UNITED STATES DEPARTMENT OF LABOR
  - **AENOR website:** AENOR
  - **Journals in Ophthalmology, Optometry, etc.**

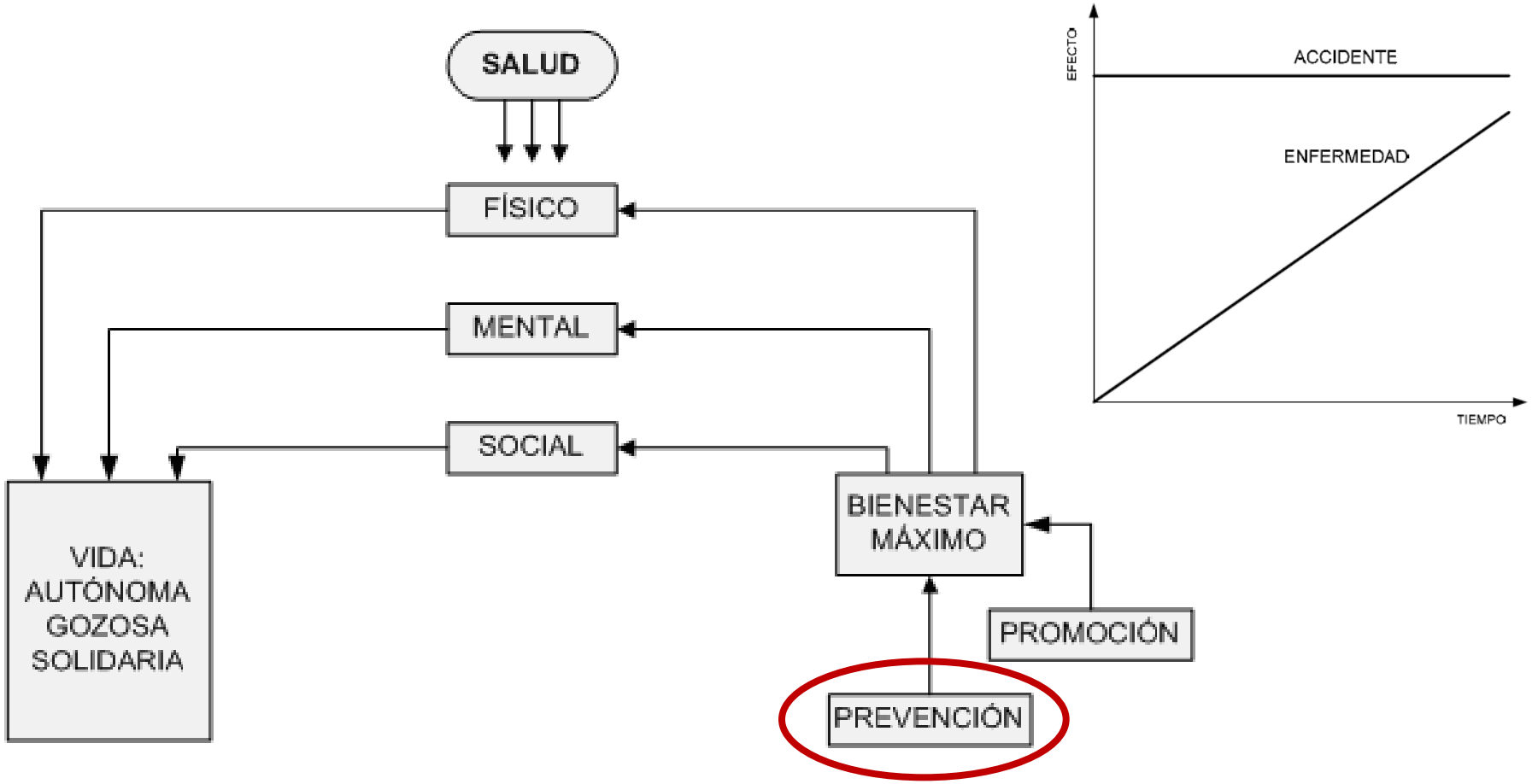
Visual Health & Work

- **Ergonomics and its link with Occupational Health**
  - **First: to get a safe task**
  - **Second: to fit it at comfortable level**
  - **Senses & Cognition**
    - **Stress and workload**
    - **Decision making**
  - **Control & Prevention**
    - **Safety, accidents and human error**
  - **Engineering anthropometry**
    - **Biomechanics of work**
    - **Work physiology**
  - **Work-space design**



Visual Health & Work

- **Occupational Health: occupational illness vs. accident**



Occurrence of eye injuries (I)

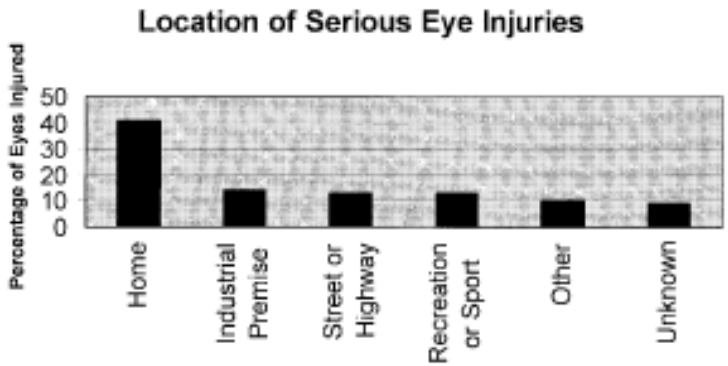
- **Eye injuries are far more common than believed in Western countries:**
  - **USA: 685/day, 7 by 1000 people in 2006**
  - **Spain: 3.6 by 1000 people in 2004, > 50000 people/year**

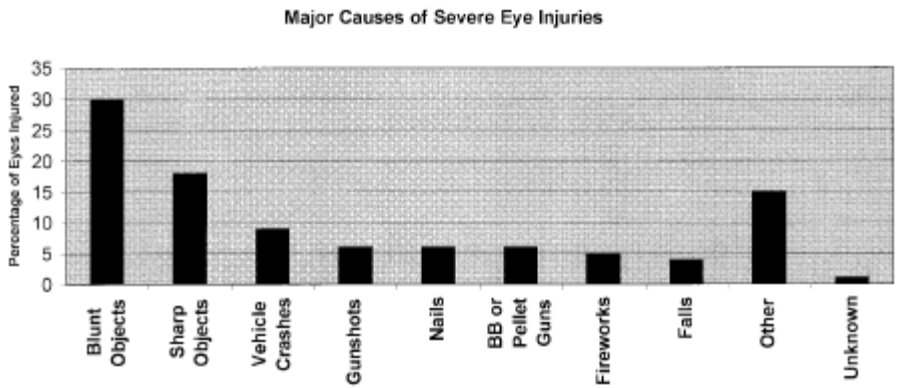
- **These injuries are often preventable (< 90 %) if workers take just put your eye protection equipment**

- **Conditioning work**
  - **Personal injury ↔ 20% runtime errors**
  - **Economic damage to the company, public administration ↔ 80% mismanagement**

Occurrence of eye injuries (II)

- **Statistical data from USA (May, et al. 2000):**
  - **> 2.5 million eye injuries and 50000 people permanently lose part or all their vision**
  - **> 45 % of all eye injuries occur in people 18 to 45 years of age**
  - **> 70 % in males**
  - **> 40 % happen in the home**
  - **> 15 % during sports, very common in children age 5 to 14**





Occurrence of eye injuries (III)

- **Statistical data from Torino-Italia during 2006:**

Table 1 Number and percentage of injuries according to the place of occurrence

	School *n* (%)	Work *n* (%)	Home *n* (%)	Motor-vehicle *n* (%)
Adnexal	24 (0.23%)	34 (0.32%)	38 (0.36%)	13 (0.12%)
Closed globe	478 (4,50%)	5999 (56,49%)	3696 (34.80%)	258 (2.43%)
Open globe	2 (0.02%)	40 (0.38%)	36 (0.34%)	2 (0.02%)

n = number of injured patients % = percentage on total eye trauma

Table 3 Number and percentage of open eye injuries according to the place of occurrence

	School *n* (%)	Work *n* (%)	Home *n* (%)	Motor-vehicle *n* (%)
Rupture	0	3 (0.28%)	5 (0.05%)	0
Penetrating injury	2 (0.02%)	25 (0.24%)	21 (0.20%)	2 (0.019%)
IOFB	0	10 (0.09%)	10 (0.09%)	0
Perforating injury	0	2 (0.02%)	0	0

n = number of injured patients % = percentage on total eye trauma

Table 4 Percentage and age-corrected incidence according to the site of injury

	0–14 I (%)	15–24 I (%)	15–44 I (%)	45–64 I (%)	65>I (%)
Adnexal	18.1 (0.18%)	6.86 (0.05%)	0	0	0
Ipoema	1.9 (0.02%)	1.37 (0.01%)	0	0	0
Retinal edema	98 (0.97%)	48.05 (0.33%)	1.09 (0.03%)	0	0
Retinal detachment	1.9 (0.02%)	0	0	0	0
Conjunctival and corneal abrasion, corneal foreign body	177 (1.75%)	70.02 (0.50%)	23.81 (0,61%)	11.75 /0,26%)	0.80 (0,02%)
Rupture	0	0	0	0	0
Penetrating	1.9 (0.02%)	1.9 (0,02%)	0	0	0
Intra ocular foreign body	0	0	0	0	0

Occurrence of eye injuries (IV)

- **Pediatric eye injuries in USA (2001-2007):**

Table 2 Diagnoses and causes of pediatric eye injuries treated in United States emergency departments, 2001–2007

Variable	Sample size	National estimates (95% confidence interval)[a]	Percent of emergency department visits
Diagnoses			
Contusion/abrasion	13,186	562,836 (468,035–657,638)	54%
Foreign body	2,885	161,187 (130,127–192,247)	15%
Conjunctivitis	1,758	91,203 (68,648–113,758)	9%
Hemorrhage	1,231	43,335 (31,887–54,784)	4%
Burn	934	54,336 (40,795–67,877)	5%
Laceration/puncture	679	30,627 (24,038–37,217)	3%
Hematoma	135	7,568 (5,286–9,851)	1%
Other[d]	2,328	97,407 (71,452–123,361)	9%
Causes			
Struck by/against	14,190	593,759 (491,760–695,758)	57%
Foreign body	3,714	204,510 (166,136–242,885)	20%
Fire/burn	2,350	124,722 (101,973–147,471)	12%
Fall	436	15,526 (12,685–18,367)	1%
Motor vehicle–occupant	330	13,939 (11,009–16,870)	1%
Cut/pierce	312	12,899 (9,038–16,759)	1%
Other bite/sting	235	9,344 (6,231–12,456)	1%

Occurrence of eye injuries (V)

- **Eye injuries in the elderly from consumer products in USA (2001-2007):**

Table 4 Consumer products: leading causes of eye injuries

Consumer product	Sample Size[a]	% of ED[b] visits	National estimates[c] *n* (95 % CI)
Chemical	322	22 %	15,236 (13,482, 16,989)
Cutting tools/construction	277	21 %	14,524 (12,777, 16,272)
Furniture	252	15 %	10,145 (8,724, 11,566)
Gardening	188	14 %	9,467 (8,021, 10,912)
Household items	126	7 %	5,022 (4,004, 6,040)
Appliances	65	4 %	3,081 (2,226, 3,936)
Household tools	51	3 %	2,331 (1,591, 3,070)
Sports equipment	49	3 %	2,276 (1,559, 2,993)
Office supplies	36	3 %	1,570 (968, 2,173)
Glasses	34	2 %	1,379 (830, 1,929)
Vehicles	13	1 %	806 (343, 1,270)
Miscellaneous	42	3 %	2,027 (1,337, 2,716)
Total	1,455	100 %	67,864 (65,850, 69,878)

[a]Number of eye injury cases caused by listed consumer product
[b]Emergency department
[c]Weighted frequencies projected by CPSC-NEISS

Table 5 Leading diagnoses of eye injuries

Diagnoses	Sample size[a]	% of ED[b] visits	National estimates[c] *n* (95 % CI)
Contusion/abrasion	588	39.7 %	26,968 (24,850, 29,086)
Foreign body	248	18.5 %	12,586 (10,952, 14,220)
Conjunctivitis	160	11.4 %	7,765 (6,439, 9,091)
Hemorrhage	106	7.0 %	4,745 (3,731, 5,759)
Burn	76	6.0 %	4,045 (3,056, 5,034)
Laceration/puncture	57	3.3 %	2,262 (1,560, 2,963)
Hematoma	38	2.6 %	1,792 (1,144, 2, 441)
Other	182	12.3 %	8,347 (7,012, 9,682)
Total	1,455	100 %	67,864 (65,850, 69,878)

[a]Actual number of injuries reported by CPSC-NEISS
[b]Emergency department
[c]Weighted frequencies projected by CPSC-NEISS

Occurrence of eye injuries (VI)

- **Sports-related eye injuries in USA (2001-2009):**

Table 1 Selected sports by risk category and eye injury rates (injuries/10,000 participants)

Sports	Injury rate
Overall	0.64
High risk	1.51
BB and paintball	2.92
Basketball	2.16
Baseball	1.62
Softball	0.67
Ice hockey	0.15
Moderate risk	0.80
Tennis	0.77
Soccer	1.09
Volleyball	0.28
Football	2.16
Fishing	0.19
Golf	0.33
Low risk	0.22
Swimming	0.35
Snow skiing	0.14
Water skiing	0.070
Bicycle	0.40
Snowboarding	0.13
Eye safe	0.045
Exercise (jogging, running, walking, aerobics)	0.045

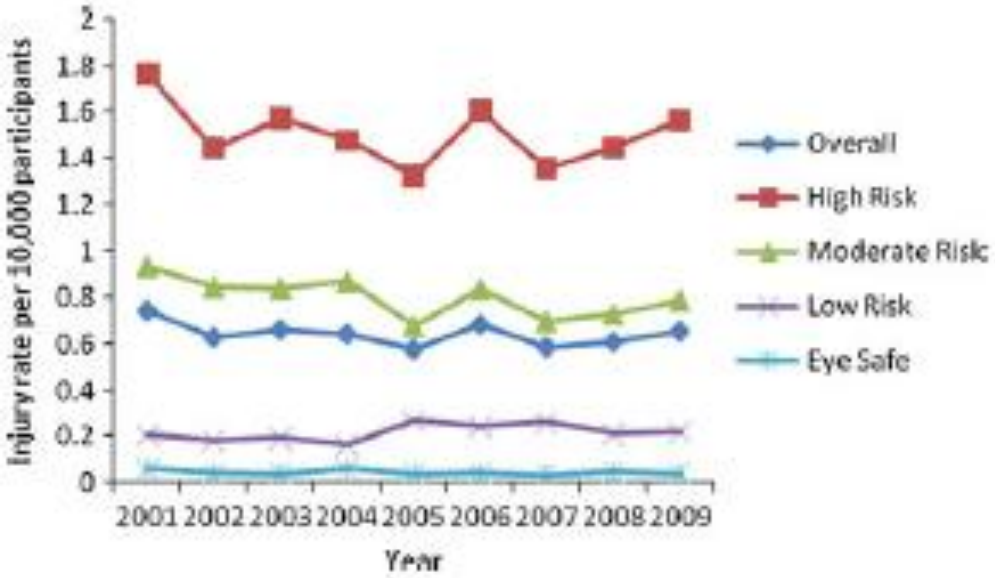


Fig. 1 Average rate of eye injury by risk category

Occurrence of eye injuries (VII)

- **Epidemiology of ocular chemical burn injuries in USA:**

Table 2.1 Some chemical substances reported to cause ocular chemical injury

Chemical substance	References
Acids (not further specified)	[28, 30, 35]
Alkalis (not further specified)	[23, 30]
Aluminum hydroxide	[30]
Ammonia	[22, 27]
Ammonium hydroxide	[30]
"Black liquor" (a heated mixture of sodium carbonate, sodium hydroxide, sodium thiosulfate, and sodium sulfate)	[34]
Calcium hydroxide	[30]
Chili powder	[30]
Corrosive substances	[18]
Cracker powder	[30]
Endoxan injection	[30]
Fish bile	[6]
Hydrochloric acid	[30]
Hydrofluoric acid	[30, 33]
Kerosene oil	[30]

Lost work days	Percent
1 day	28.8%
2 days	19.0%
3–5 days	24.7%
4–20 days	7.6%
21–30 days	2.4%
31 days or more	7.8%

Kerosene oil	[30]
Lye	[24, 25]
Methanol	[30]
Nitric acid	[30, 33]
Oxalic acid	[30]
Paint	[30]
Phenol	[30]
Savion	[30]
Sodium hydroxide	[30]
Sulfuric acid	[30]
Unknown	[30]

Occurrence of eye injuries (VIII)

- **Statistical data in Spain (Carrasco PhD, 2005, vs. 2011):**

LOCALIZACION DEL AT CON BAJA	TOTAL DE ACCIDENTES DE TRABAJO CON BAJA					
	AÑO 1999		AÑO 2000		AÑO 2001	
	IND INC	Nº AT BAJ	IND INC	Nº AT BAJ	IND INC	Nº AT BAJ
TOTAL	7437,37	869.161	7558,39	932.932	7329,81	944.013
Cráneo	97,99	11.451	96,19	11.873	95,17	12.257
Cara excepto ojos	85,24	9.962	84,31	10.406	82,17	10.583
Ojos	473,35	55.318	438,98	54.183	424,03	54.611
Cuello	205,60	24.027	244,45	30.172	235,41	30.319
Tórax, espalda y costados	877,07	102.498	938,99	115.899	908,95	117.065
Regiones lumbar y abdominal	672,21	78.557	700,90	86.512	674,24	86.836
Genitales	5,44	636	5,96	736	5,82	749
Manos	1851,35	216.356	1840,61	227.186	1784,57	229.836
Miembros superiores (excepto manos)	919,15	107.415	930,79	114.888	902,65	116.253
Pies	975,71	114.025	978,95	120.832	946,89	121.951
Miembros inferiores (excepto pies)	1099,22	128.459	1128,21	139.255	1097,72	141.376
Lesiones múltiples	146,78	17.153	142,90	17.638	143,76	18.515
Órganos internos	28,27	3.304	27,16	3.352	28,43	3.662

	Frecuencia	Porcentaje	IC 95%
Soldador, montador	68	38,4	31,40 – 46,25
Mantenimiento	40	22,6	1,62 – 3,08
Maquinista	17	9,6	5,72 – 15,01
Serrador	13	7,3	3,99 – 12,29
Pulimentador	12	6,8	3,57 – 11,6
Recogedor	9	5,1	2,36 – 9,48
Pintor	6	3,4	1,26 – 7,27
Encofrador	5	2,8	0,92 – 6,50
Oficinista	4	2,3	0,62 – 5,71
Conductor	2	1,1	0,13 – 4,04

N=176 P<0,05

	Frecuencia	Porcentaje	IC 95%
Metal	67	37,9	30,86 – 45,67
Maderas	59	33,3	26,59 – 41,01
Agrícola	11	6,2	3,16 – 10,90
Construcción	10	5,6	2,75 – 10,20
Almacén	9	5,1	2,36 – 9,48
Plásticos	9	5,1	2,36 – 9,48
Mantenimiento	8	4,5	1,98 – 8,75
Papelera	3	1,7	0,35 – 4,90

AÑO 2001	GANANCIA ANUAL POR TRABAJADOR	G.A POR T. EN EUROS CONSTANTES	PERDIDA POR DURACION MEDIA DE UNA BAJA	P.P.D.M.B EUROS CONSTANTES	PORCENTAJE DE PERDIDA DEL SALARIO
TOTAL	16.412,16	149,72	1.792,99	16,36	10,92%
INDUSTRIA	18.406,57	167,91	1.879,68	17,15	10,21%
CONSTRUCCION	14.677,38	133,89	1.455,06	13,27	9,91%
SERVICIOS	16.051,09	146,42	1.837,96	16,77	11,45%

	PERDIDA AÑO 2001
TOTAL	15.469.090
INDUSTRIA	4.567.471
CONSTRUCCION	3.328.623
SERVICIOS	6.564.127

Prevention of eye injuries (I)

- **Relative importance of all eye injuries:**

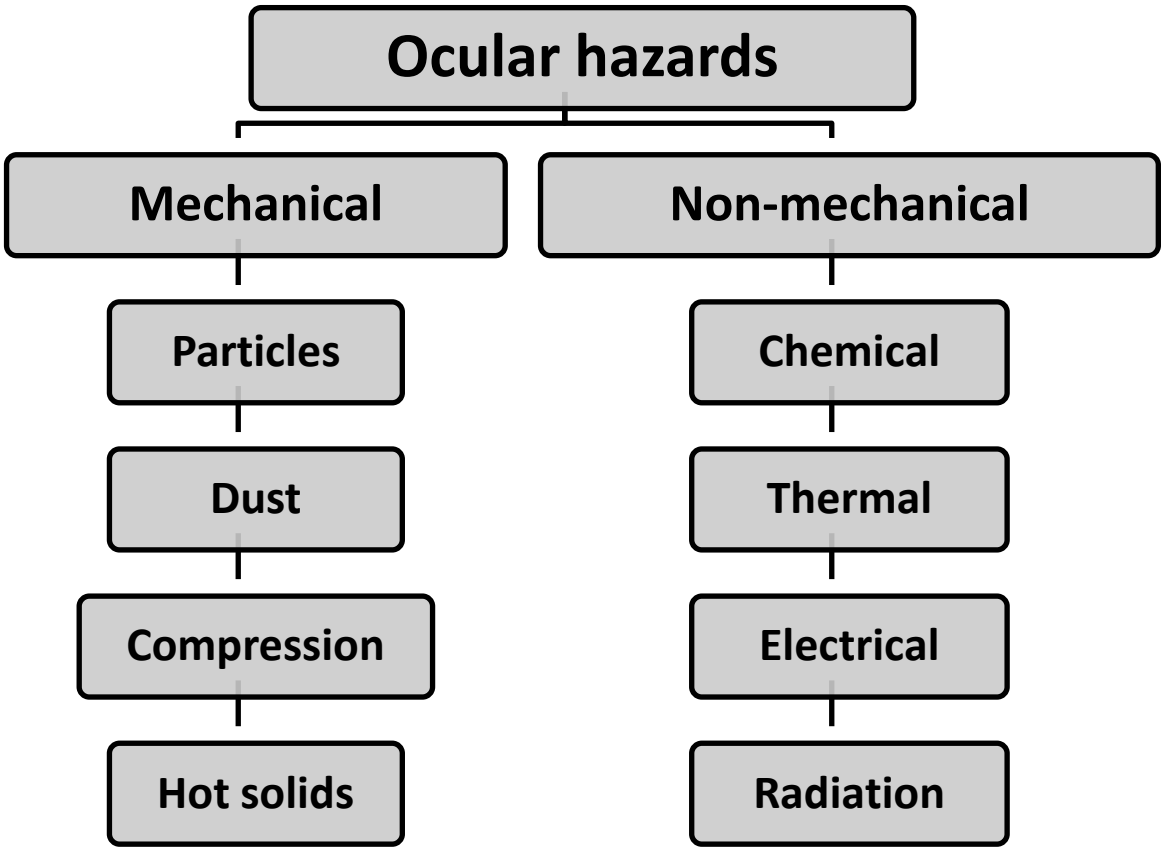
Hazard type	Risk factor	Commonly related tasks
Hit	Flying objects such as chips, fragments, particles, sand or earth	Cutting, grinding, masonry, carpentry, sawing, drilling, riveting, sanding, etc.
Heat	Any hot object	Any type of oven or stove, etc.
Bio & Chemical Agents	Spray, gases, vapors and irritating mists	Handling chemicals, degreasing, laminate, and any blood work
Dust	Harmful dust	Carpentry, general dirt, etc.
Optical Radiation	Radiant energy, glare and intense light	Welding arcs, melting furnaces, lasers, lamps, etc.

Prevention of eye injuries (II)

- **Role of the optometrist / medical professions**
  - **Incorporation in inter and multi-disciplinary teams related with occupational health**
- **Perception of risk**
  - **Educational and training campaigns using veteran workers**
- **Eye protection programme**
  - **Plant environmental survey**
  - **Vision screening**
  - **Implementation of the programme**
  - **Maintenance of the programme**
    - **Security signaling (ISO 70140)**

Mechanical eye injuries (I)

- **Initial classification by North (2001)**



Mechanical eye injuries (II)

- **BETT = Birmingham Eye Trauma Terminology (2008)**

Table 1.1.3 Terms and definitions in BETT

Term	Definition	Comment
Eye wall	Sclera and cornea	Though the eye wall has three layers posterior to the limbus, clinical and practical purposes dictate that violation of only the most external tissue (sclera) is to be considered
Closed globe injury	No full-thickness wound of eye wall	The cornea and the sclera are not breached through and through
Open globe injury	Full-thickness wound of the eye wall	The cornea and/or sclera is breached through and through
Contusion	No wound of the eye wall	The damage may be due to direct energy delivery/shock wave by the object (e.g., choroidal rupture), or to changes in the shape of the globe (e.g., angle recession)
Lamellar laceration	Partial-thickness wound of the eye wall	The wound in the eye wall is not "through" but "into"
Rupture	Full-thickness wound of the eye wall, caused by a large blunt object	Since the eye is filled with incompressible liquid, the impact results in instant IOP elevation. The eye wall yields at its weakest point (rarely at the impact site, rather, for instance, along an old cataract wound); the actual wound is produced by an inside-out mechanism, and tissue prolapse is almost unavoidable

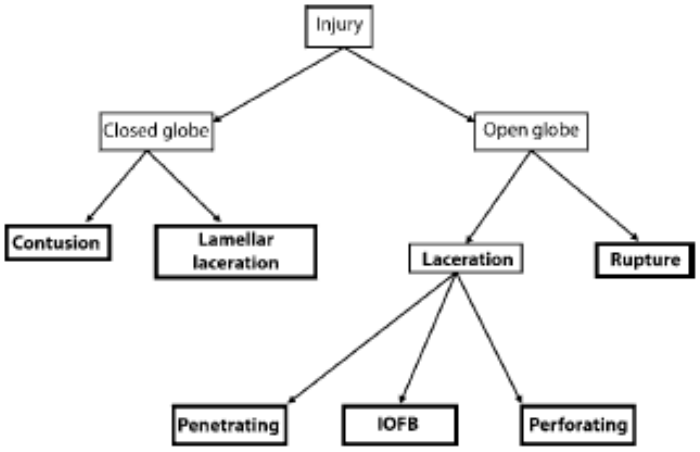
Some injuries have a complex mechanism and are thus difficult to classify (e.g., an intravitreal BB pellet is technically an IOFB injury, but since this blunt object requires great force to enter the eye, the wound is created as if it were a rupture; see the text for more details). In such situations, the ophthalmologist can describe the injury as "mixed" (i.e., rupture with an IOFB) and select the more serious type (rupture), or the one that dominates the acute management (IOFB). Complete destruction of the eye and traumatic enucleation (see Fig. 1.1.5) are not included in the system

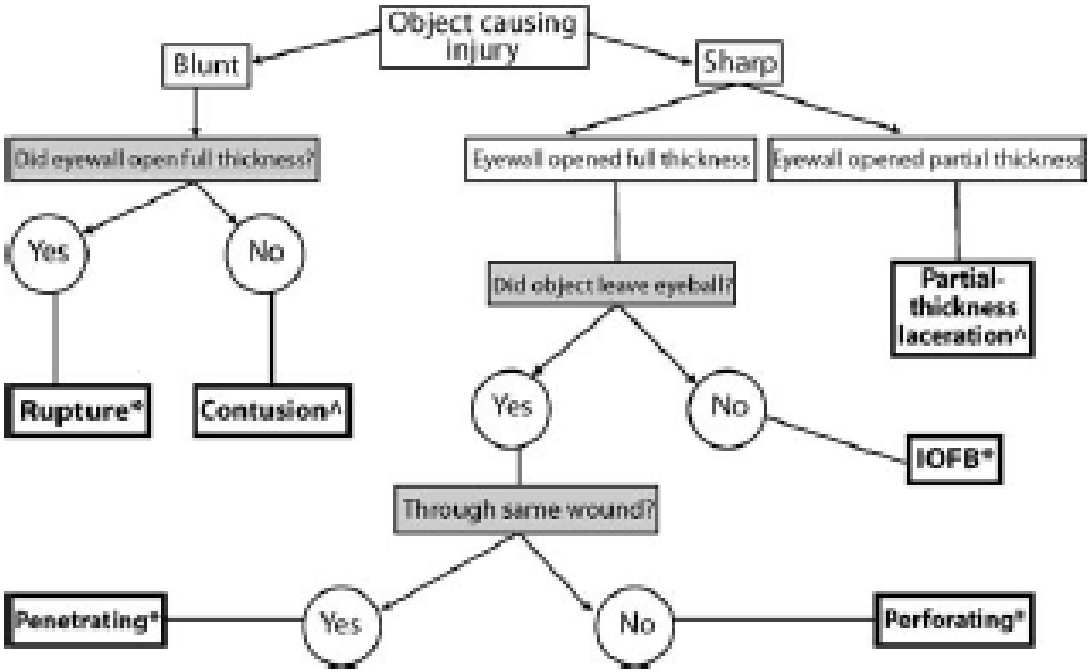
Table 1.1.3 *(continued)* Terms and definitions in BETT

Term	Definition	Comment
Laceration	Full-thickness wound of the eye wall, caused by a sharp object	The wound is at the impact site and is created by an outside-in mechanism; since IOP elevation is unavoidable, tissue prolapse is common
Penetrating injury	An entrance wound is present	If more than one wound is present, each must have been caused by a different object
IOFB	One or more foreign objects are present	Technically a penetrating injury, but grouped separately because of different clinical implications (management, prognosis)
Perforating injury	Both an entrance and an exit wound are present	The two wounds caused by the same agent

Mechanical eye injuries (III)

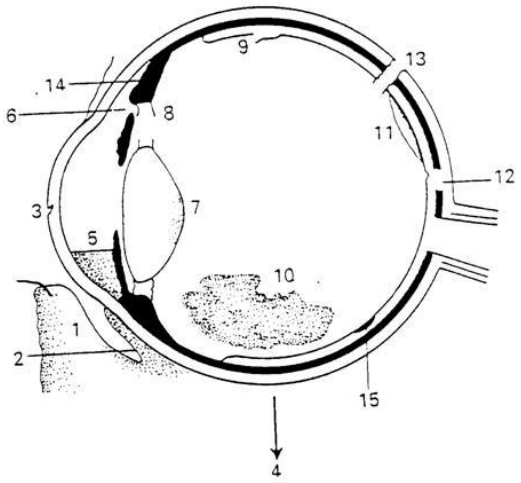
- **BETT = Birmingham Eye Trauma Terminology (2008)**
  - **Primary eye care and treatment by ophthalmologists**
  - **Ocular Trauma Score: predicting the severity**





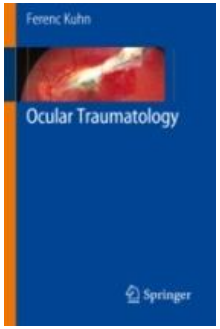
Mechanical eye injuries (IV)

- **Contusion injuries:**
  - **Causes (risk factors):**
    - **flying blunt objects, falling object, explosions or compressed air accidents, water jets, airbag inflation, etc.**
  - **Mechanism damage:**
    - **pressure wave traversing the (incompressible) eye fluid content**
    - **1: black eye; 2: subconjunctival haemorrhage;**
    - **3: corneal abrasion; 4: blow-out fracture;**
    - **5: hyphaema; 6: iridodialysis;**
    - **7: cataract; 8: lens subluxation due to torn zonule;**
    - **9: retinal tear/detachment; 10: vitreous haemorrhage:**
    - **11: commotio retinae; 12: choroidal rupture;**
    - **13: scleral rupture; 14: angle recession; 15: retinal haemorrhage.**



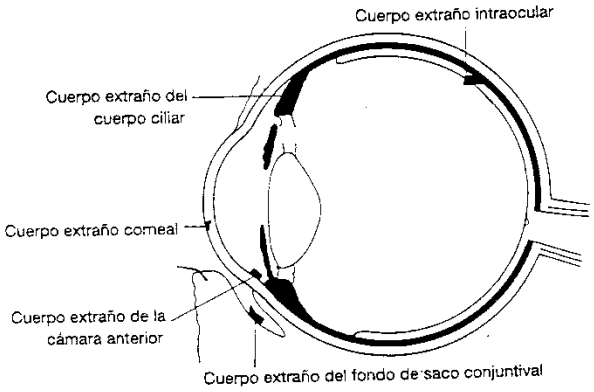
Mechanical eye injuries (V)

- **Examples of contusion injuries and glossary in zones:**
  - **Eyelids and orbit:**
    - **Black eye, ptosis, ectropion, fractures of the orbit**
  - **Anterior segment:**
    - **Subconjunctival haemorrhages, hyphaema, iris, angle recession**
    - **Lens: vossius ring opacity, sub-epithelial disseminated opacities, traumatic rossette-shaped or diffuse or zonular cataract**
  - **Posterior segment damage:**
    - **Oedema, cysts, holes, necrosis**
    - **Vascular changes, tears of the choroid and retina,**
    - **Retinal detachment**
    - **Nervous supply**

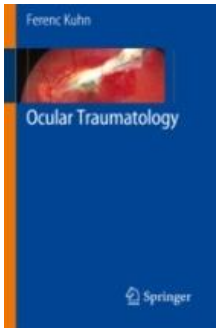


Mechanical eye injuries (VI)

- **Perforating injuries:**
  - **Foreign bodies (FB): subtarsal, superficial,**
  - **Intraocular foreign bodies (IOFB):**
    - **Methods of localization:**
      - **Non-metallic fragments: ultrasonography**
      - **Metallic fragments: X-rays**
    - **Retained IOFB:**
      - **Bio fragments causes infections (uveitis, etc)**
      - **Maximum danger: Fe (siderosis), Cu (chalcosis)**
  - **Lacerations:**
    - **Cornea and sclera, prolapse of the iris, ciliary body, etc**
    - **Complete disorganization of the globe**



Localizaciones de los cuerpos extraños oculares.

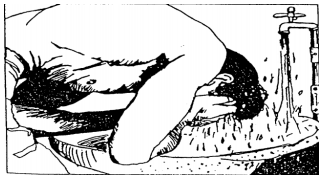


Non-mechanical eye injuries (I)

- **General classification (North 2001):**
  - **Chemical**
    - **Direct vs. indirect effect according to different chemical substances**
  - **Thermal**
    - **Thermal, flame, contact burns and scalds**
  - **Electrical**
    - **Due to lightning and high-tension electrical appliances**
  - **Radiation**
    - **Ionizing (α, β, γ, X): cataract after ocular tumor treatment**
    - **Optical (UV, VIS, IR) → Lesson no. 4**
    - **Non-optical (MO, RF, etc)**

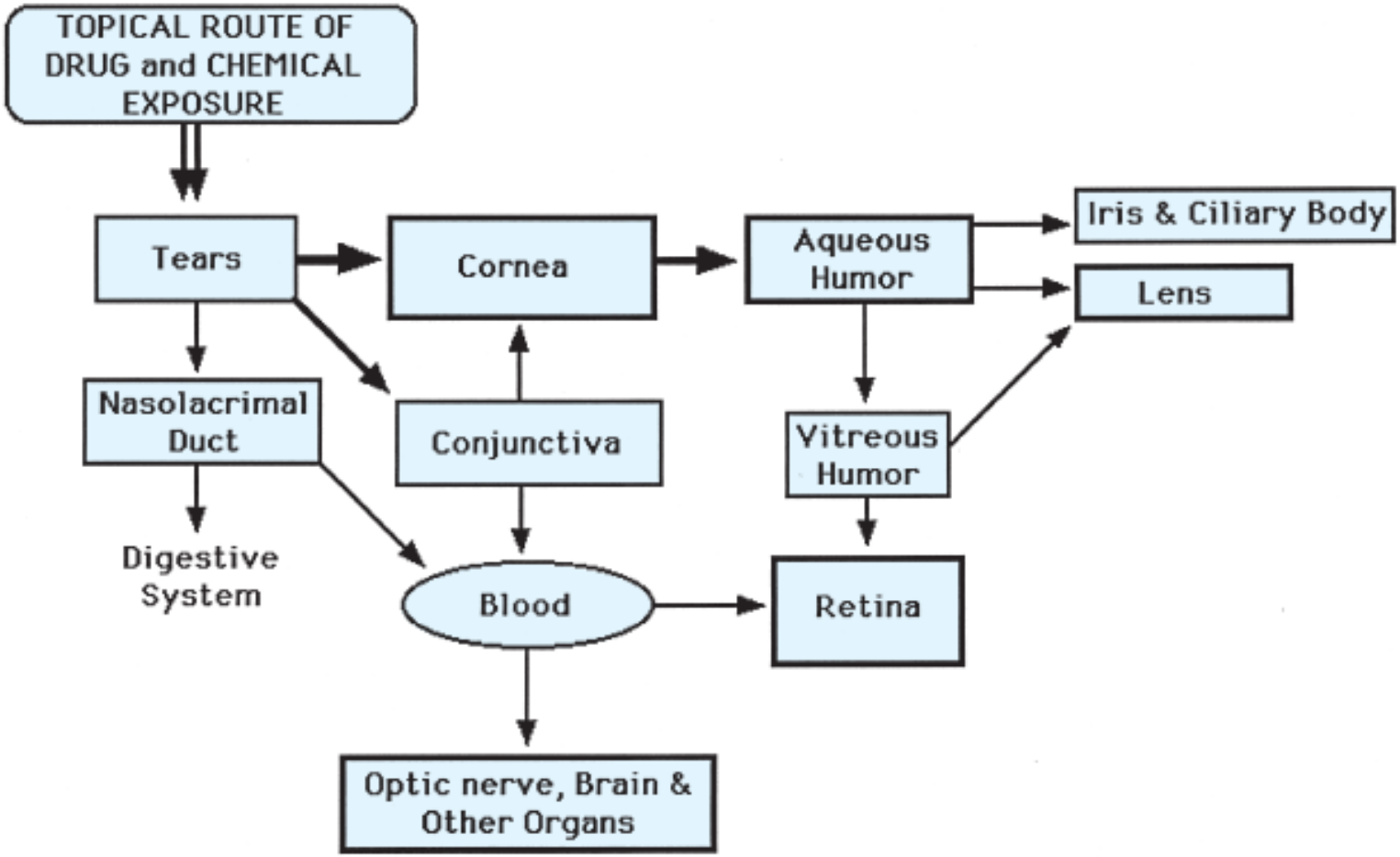
Non-mechanical eye injuries (II)

- **Chemical agents:**
  - **Direct effect (by contact)**
  - **Indirect effect (by ingestion, absorption or inhalation)**
  - **Variables:**
    - **Concentration, pH, exposure time**
  - **Treatment by acids, alkalis, organic solvents, etc**
    - **Prognosis for eyes subjected to chemical burns**
      - **Grade I-IV (excellent to very poor)**
    - **Chemical neutralization of harmful substance**
      - **With water or saline: nearby presence of showers**
      - **Alkalis + Acid = WATER**
        - **pH > 11 max. danger**



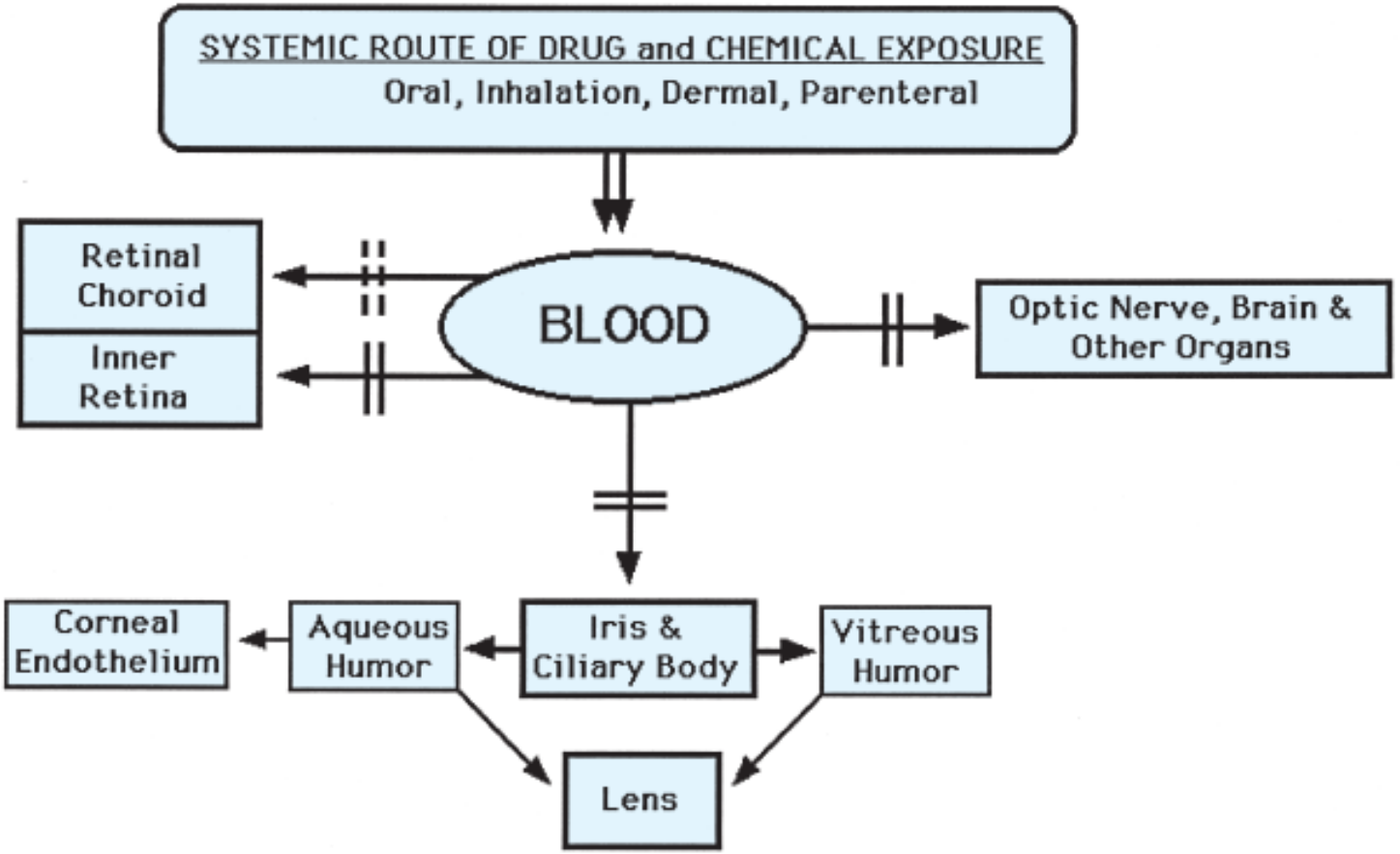
Non-mechanical eye injuries (III)

- **Chemical agents: topical route of exposure**

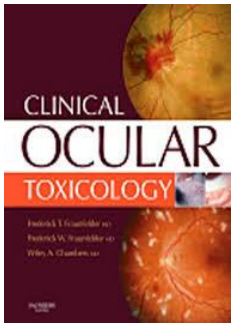


Non-mechanical eye injuries (III)

- **Chemical agents: distribution following the systemic route of exposure**



Non-mechanical eye injuries (IV)



- **Chemical agents:**
  - **Toxic responses of the ocular and visual system**
    - **Drugs, herbal medicines, chemical agents**
  - **Methods for evaluating chemical-induced visual side effects**
    - **Functional tests**
      - **VA, color vision, visual field, CSF, ERG, photostress tests, double vision and ocular motility, pupil measurements, corneal sensitivity & thickness**
    - **Objective anatomical methods**
      - **Cornea and conjunctiva, tear film;**
      - **Lens, anterior chamber**
      - **Retina, intraocular pressure**

Design of eye protection equipment

- Definition
- General requirements
- Typical forms
- Materials for lenses
- Materials mounts
- Control Tests
  - Physico-chemical factors
  - Spectral factors

Design of eye protection equipment

- **Definición (R.D. 773/1997, de 30 mayo)**
  - **EPI = “cualquier equipo destinado a ser llevado o sujetado por el trabajador para que le proteja de uno o varios riesgos que puedan amenazar su seguridad o su salud, así como cualquier complemento o accesorio destinado a tal fin”**
  - **Excluidos:**
    - La ropa de trabajo corriente y los uniformes que no estén específicamente destinados a proteger la salud o la integridad física del trabajador.
    - Los equipos de los servicios de socorro y salvamento.
    - Los equipos de protección individual de los militares, de los policías y de las personas de los servicios de mantenimiento del orden.
    - Los equipos de protección individual de los medios de transporte por carretera.
    - El material de deporte.
    - El material de autodefensa o de disuasión.
    - Los aparatos portátiles para la detección y señalización de los riesgos y de los factores de molestia**.**

Design of eye protection equipment

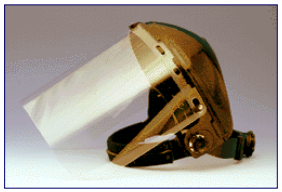
- **General requirements**
  - **Safe**
    - **constructed so that it does not impair visual function**
  - **Efficacy:**
    - **constructed to provide the necessary protection against the hazard for which it is designed**
  - **Comfort: during wear and not liable to condensation**
  - **Lightweight: and not interfere with movements**
  - **Easily cleaned**
  - **Readily replaced at reasonable cost**
  - **Durable, non-flammable and non-irritant to the skin**
  - **Of suitable optical quality**
  - **Cosmetically acceptable**
  - **Compatible with other protective devices**

Design of eye protection equipment

- **Typical forms: INSHT website**
  - **Eyeshield**

  - **Eyeshield integral (uni or biocular)**
  - **Cups rimmed glasses (goggles)**

  - **Face shields**



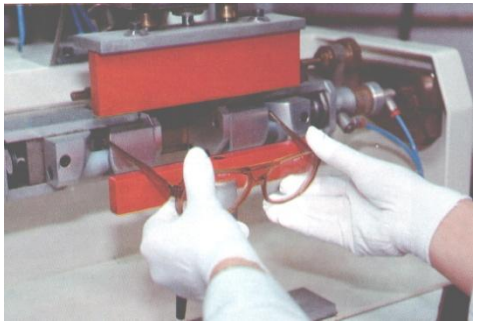
  - **Welding screens (hand, head, helmet attachable to the industry)**

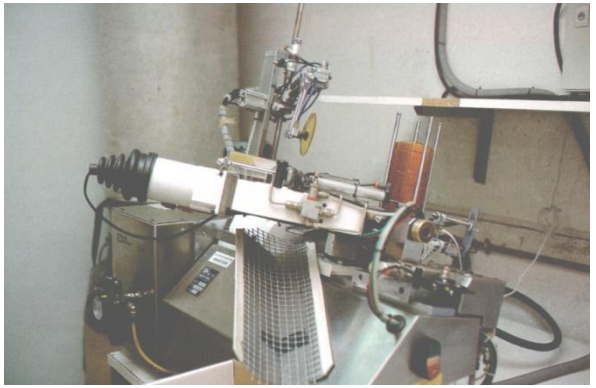
Design of eye protection equipment

- **Employers should ensure that workers wear PPE required optical prescription required prescription that incorporate or use PPE on his regular spectacle**
- **Materials for lenses**
  - **Glass (crown)**
  - **Plastic (CR-39, PMMA, polycarbonate)**
  - **Wire netting**
- **Materials mounts**
  - **Metal (Ni alloy)**
  - **Injected plastics: polycarbonate, polyamide, etc.**

Design of eye protection equipment

- **Tests of physical control - chemical (I)**
  - **Impact resistance**
  - **Points to check:**
    - **Abrasions / scratches surface**
    - **Size / velocity of the projectile**
    - **Lens thickness**
    - **Material type**
  - **Comments:**
    - **↓ Resistance in P_f'<0**
    - **Permanent radial fractures optical glass**
    - **Shear fractures and fragments in CR-39**





Design of eye protection equipment

- **Tests of physical control - chemical (II)**
  - **Hardness**
  - **Chemical resistance**
    - **Glass and CR-39: quite resistant**
  - **Thermostability**
    - **Polycarbonate and PMMA tend to distort more easily than glass**
  - **Inflammability**
    - **All plastics are flammable at very high T, never attainable in normal**
  - **Resistance to hot particles**
    - **Spotted glass resistance and worse than CR-39**
  - **Radiosensitivity**
    - **Glass detectable sizes> 0.5 mm**
    - **Plastic, very difficult to observe**

Design of eye protection equipment

- **Tests of optical quality**
  - **Polishing**
  - **Spectral requirements for:**
    - **Solar protection**
    - **Welding arcs**
    - **Lasers**
    - **Glare**

Standards related to eye protection

- **AENOR + INSHT websites:**
  - **Basic use (166)**
  - **Impact (166, 1731)**
  - **Fluids (166)**
  - **Coarse powder (166)**
  - **Gas and fine dust (166)**
  - **Solar radiation (166, 172)**
  - **Radiation IR / radiant heat (166, 171, 1731)**
  - **UV radiation (166, 170, 169)**
  - **Welding radiation (166, 169, 175, 379)**
  - **Laser radiation (166, 207, 208)**
  - **Molten metals (166)**
  - **Short circuit electric arc (166)**

Standards related to eye protection

- **UNE EN - 166: http://www.aenor.es (DOFA analysis)**
- **Classification of performance**
  - **Filter code (optical)**
    - **s / n: welding filter**
    - **2: UV filter**
    - **3: VIS filter**
    - **4: IR filter**
    - **5: Sunscreen without IR requirements**
    - **6: Sunscreen with IR requirements**
  - **Degree of protection**

$$N = 1 + \left(\frac{7}{3}\right)\log\left(\frac{1}{\tau_V}\right) \quad , \quad \text{with } \tau_V = \frac{\Phi_{TOTAL}\ \text{transmitted}}{\Phi_{TOTAL}\ \text{incident}} = \frac{\sum_{380nm}^{780nm} F_e(\lambda)\tau(\lambda)V(\lambda)\Delta\lambda}{\sum_{380nm}^{780nm} F_e(\lambda)V(\lambda)\Delta\lambda}$$

Final message

When workers are trained to work safe, be able to anticipate and avoid work-related injuries

Supplementary reading and learning

- **Download the MEDOP catalogue from lesson folder**
  - **Read the ocular and facial section**
  - **Why it is interesting?**
  - **Applicability level?**
  - **Work opportunities?**
  - **From other similar companies?**

Proposed activity nº 4

- **Relative Weight: 2.5 %**
- **Delivery process by Virtual Campus, section forum**
- **Individual Task:**

  - **Download and read the next book chapter: "Toxic responses of the ocular and visual system", by D.A. Fox & W.K. Boyes, from *Casarett & Doull's Essentials of Toxicology*, 2nd edition (2010).**

  - **Which topics have been very surprised for you? Why?**

  - **What prevention mechanisms would you propose or improve by new research activities?**