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Occupational medicine in Germany – with special focus on occupational cancer. Review and critical discussion

La medicina del lavoro in Germania, con particolare riguardo ai tumori professionali

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Summary

Aim. **Description of the legal framework of occupational medicine in Germany with emphasis on the reported and notified cases of occupational cancer.** ***Methods.*** **Description and review of the current legislation and statistical data from the German: Documentation of the Occupational Disease Occurrence.** ***Results.*** **The dual German occupational health system is rather complex with different responsibilities of several stakeholders involved. Due to changes of legislation the number of notified occupational diseases shows some variation over the past. In 2010, 73.425 cases have been notified based on a suspicion on the existence of an occupational disease, of which a quarter has been accepted and 10% has been compensated. Occupational cancers are mainly related to asbestos (75%), followed by exposure to ionizing radiation (10%) and aromatic amines (5%). The incidence of some occupational cancers is still on the rise; most importantly the peak for**

Riassunto

Finalità. **Descrizione della situazione legale della medicina occupazionale con particolare enfasi sui casi segnalati e notificati come tumori professionali in Germania.** ***Metodi.*** **Descrizione e revisione dell'attuale legislazione e dei dati statistici provenienti dal tedesco: Documentazione sulla Insorgenza delle Malattie Professionali.** ***Risultati.*** **Il sistema sanitario occupazionale tedesco, di tipo duale, è piuttosto complesso, con differenti responsabilità di molte parti interessate. A causa dei cambiamenti legislativi, il numero delle malattie professionali notificate mostra alcune variazioni rispetto al passato. Nel 2009, sono stati notificati 70.100 casi sulla base di un sospetto a proposito dell'esistenza di una malattia professionale. Un quarto del totale è stato riconosciuto e il 10% è stato indennizzato. I tumori professionali vengono correlati soprattutto all'amianto (75%), seguiti da quelli dovuti all'esposizione e alle radiazioni ionizzanti (10%) e ad amine aromatiche**

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mesothelioma incidence has not been reached yet. *Conclusions.* Recognition of an occupational disease and receiving compensation is confined to listed diseases and stringent criteria of exposure and diagnostic parameters. In other cases it allows few workers actually to receive compensation. Mainly for asbestos related occupational lung and larynx-cancers with long latency periods under reporting must be assumed. Comparison with other European countries indicates heterogeneous recognition procedures, with considerable differences in accepted cases between countries. A harmonized thorough European documentation of occupational diseases and occupational cancers should be pursued in the interest of occupational justice and primary prevention. Eur. J. Oncol., 17 (3), 113-134, 2012

Key words: **occupational cancer, occupational disease, time trend, statutory accident insurance, registry, asbestos, ionizing radiation, hazardous chemicals**

(5%). L'incidenza di alcuni tumori professionali è ancora in aumento, in particolare il picco di incidenza del mesotelioma non è stato ancora raggiunto. *Conclusioni.* Per poter confrontare i dati dei diversi paesi è necessario essere consapevoli che esistono delle differenze metodologiche tra i paesi stessi per quanto riguarda le procedure legali e i codici così come la fonte e la qualità dei dati. Le limitazioni del sistema di segnalazione tedesco che sono state identificate richiedono un intervento. Nell'interesse della giustizia professionale e della prevenzione primaria, sarebbe necessario raggiungere una armonizzazione attraverso una documentazione europea sulle malattie e sui tumori professionali. Eur. J. Oncol., 17 (3), 113-134, 2012

Parole chiave: **tumore professionale, malattia professionale, tendenza temporale, assicurazione obbligatoria contro gli infortuni, registro, amianto, radiazione ionizzante, agenti chimici pericolosi**

German Occupational Health and Social Insurance System

The Federal Republic of Germany has a dual system of occupational health and safety, one pillar is provided by the state and the other by the sovereign activity of the statutory accident insurances, with self-administration on the basis of parity between employers and employees.

Occupational accident insurance was initially introduced under the social legislation of Bismarck ("Accident Insurance Act") in 1884. Today the Seventh Book of the Social Code (Sozialgesetzbuch VII, SGB VII) regulates statutory accident insurance and displays the legal basis for occupational diseases, are conclusively defined in the occupational disease regulation (Berufskrankheitenverordnung, BKV). Under the umbrella of the German Statutory Accident Insurance Association (Deutsche Gesetzliche Unfallversicherung, DGUV), nine professional associations (Berufsgenossenschaften, BGs) plus regionally organized insurance institutions of the public sector (Gesetzliche Unfallversicherung, GUV) are organized as public legal bodies under state control. The agricultural statutory accident insurance is separately organized within the same legal framework. These legal bodies are responsible for prevention and insurance for occupational diseases and work accidents. They are self-governing and a parity between employers and the insured employees is present.

Three research and service institutes are maintained by the DGUV: the "Institute for Occupational Safety and Health of the German Social Accident Insurance" (Institut für Arbeitsschutz, IFA) in Dortmund, the "Institute of Work and Health of the German Social Accident Insurance" (Institut für Arbeit und Gesundheit, IAG) together with "DGUV Academy" located in Dresden and the "Institute for Prevention and Occupational Medicine" of the German Social Accident Insurance (Institut für Prävention und Arbeitsmedizin, IPA) in Bochum.

Complete reports on up-to-date research topics are published in the form of "IFA-Reports" [formerly: BGIA-Reports (Berufsgenossenschaftliches Institut für Arbeitsschutz, BGIA) and BIA-Reports (Berufsgenossenschaftliches Institut für Arbeitssicherheit, BIA)] and reports of the German Social Accident Insurance Institutions (most of them are only available in German).

The state is represented by the Federal Ministry of Labor and Social Affairs in federal cooperation with the Ministries of Labor and/or Social Affairs of the individual German states being responsible for the organization of the work inspectorates in their state agencies and for the reporting process of all filed reports of suspected occupational diseases by the state occupational physician (Landesgewerbearzt). The state occupational physician is involved and provides medical expertise in all aspects of occupational safety and health in the Federal State (Land), e.g. occupational diseases and prevention, operational audits with the Labor Inspectorate, implementation of health and safety regulations, training and further education and research.

These workplace authorities consolidate their knowledge in the Land Committee for Industrial Safety and Safety Engineering (Länderausschuss für Arbeitsschutz und Sicherheitstechnik, LASI).

The Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, BAuA) was established by decree of the Federal Ministry of Labor and Social Affairs in 1996. It is a public-law institution without legal capacity and as a federal authority it is directly responsible to the Federal Ministry of Labor and Social Affairs (Bundesministerium für Arbeits und Soziales, BMAS). BAuA's tasks range from policy advice, the performance of sovereign duties and knowledge transfer into corporate practice up to the educational and instructional work done by the German Occupational Safety and Health Exhibition (Deutsche Arbeitsschutzausstellung, DASA). BAuA also funds research projects on occupational health.

Three advisory boards are working on behalf of the BMAS:

- The Committee on Hazardous Substances (Ausschuss für Gefahrstoffe, AGS) is responsible for establishing Technical Rules for Hazardous substances (Technische Regeln für Gefahrstoffe, TRGS), occupational exposure limits (Arbeitsplatzgrenzwerte – AGW) and maximum allowable biological concentrations for human biomonitoring (Biologischer Grenzwert- BGW).
- The Committee for Biological Agents (Ausschuss für Biologische Arbeitsstoffe, ABAS) releases technical rules for biological agents (Technische Regeln für Biologische Arbeitsstoffe, TRBA). Technical rules reflect the state of the art in industrial hygiene and other scientific knowledge for working with hazardous substances or biological agents, including their classification and labeling.
- The Committee of Occupational Medicine (Ausschuss für Arbeitsmedizin, AfAMed) adds the medical perspectives of prevention and occupational health examinations. Its members represent inter alia members of the workforce, employers, enforcing authorities, institutions of the statutory accident insurance and associations for trade and industry (Berufsgenossenschaften, BGs), and academia.

Occupational Exposure Limits (OEL)

According to the German Hazardous Substances Ordinance (Gefahrstoffverordnung) an AGW is a time-weighted average concentration in the workplace air, referring to a given period of time. Usually, existing OEL proposals developed by other organisations are evaluated, predominantly by the "Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area" (MAK-Commission), foreign OELs and OEL values indicated by the EU. The German AGWs are listed in the TRGS No. 900 and are published (in German) on the website of the BAuA.

Because health-based workplace exposure limits cannot be derived for carcinogenic, mutagenic and reprotoxic substances, the AGS recently proposed a generic concept for setting risk-based limit values for carcinogenic substances in the context of social policy. Two limits for occupational exposure-related lifetime cancer risks (acceptable risk and tolerable risk) were adopted:

I) Acceptable risk is defined as 4:10.000 (*interim* value), and 4:100.000 (as of no later than 2018). Below these limits, a risk is accepted. Above these limits, a risk will be tolerated if there is compliance with the safety measures specified in a corresponding catalogue.
II) Tolerable risk is defined as 4:1.000. This risk must not be exceeded.

The risks refer to a lifetime of 40 working years and continuous exposure every working day. Substance-specific concentrations derived from well-founded exposure-risk models are compiled in Announcement 910 and should be taken into account by employers during the performance of risk assessments. During a test phase which is to last several years and is expected to end in 2015, the risk limits and the respective substance concentrations in the workplace air will not be regarded as legally binding limit values under the German Hazardous Substances Ordinance (1).

A "Guide for the quantification of cancer risk figures after exposure to carcinogenic hazardous substances for establishing limit values at the workplace" outlines the basic principles of the approach, its rationale, examples of the approach with quantification, and a glossary (2).

Biological Limit Value (Biologischer Grenzwert, BGW)

The BGW value describes the toxicologically derived concentration of a substance, its metabolites or an effect parameter in the corresponding biological material, at which the health of an employee generally is not adversely affected even when the person is repeatedly exposed during long periods. Similarly to the OEL the BGW is derived from existing limit proposals developed by other organisations, especially the Biological Tolerance Value (Biologischer Arbeitsplatz-Toleranz-Wert, BAT) by the MAK Commission. In addition, sufficient occupational medical and toxicological data have to be available.

The MAK Commission

The MAK Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area is responsible for determining the current state of research related to health risks posed by substances and materials used at the workplace and for advising public authorities accordingly. The MAK Commission derives MAK values (maximum concentration at the workplace) for volatile chemicals and dusts, BAT values and also develops procedures to analyse chemical substances in the air and in biological materials. For establishing a MAK value, the following five properties of chemical agents are evaluated:

- carcinogenicity
- sensitizing effects
- contribution to systemic toxicity after percutaneous absorption
- risk during pregnancy
- germ cell mutagenicity

MAK values are exclusively derived on the basis of scientific evidence. First, the most sensitive parameters described in the available data are identified. The derivation of the MAK value is based on the "no observed adverse effect level" (NOAEL) for the most sensitive effect with a relevance for health. If no NOAEL can be derived from the available data, a scientifically founded MAK value cannot be established (3).

Classification of carcinogenic agents

Substances which have been shown to be carcinogenic in man or in experimental animal studies are classified by the MAK Commission in the categories 1 or 2 and are not assigned MAK or BAT values. Suspected carcinogens are classified in category 3 and are assigned a MAK or BAT value only if neither the substance nor any of its metabolites is genotoxic.

Categories 4 and 5 include substances with carcinogenic properties for which the available data are sufficient to assess the carcinogenic potency. For these substances, an OEL (MAK or BAT value) is defined at which no significant contribution to the cancer risk of the exposed persons is expected. The substances classified in category 4 are known to act typically by non-genotoxic mechanisms. Category 5 contains genotoxic carcinogens of weak potency. For the monitoring of exposure to these substances,

the establishment of BAT values is of particular importance.

The Globally Harmonized System of Classification and Labelling of Chemicals (UN-GHS) is a United Nations (UN) initiative to attempt to harmonize the different systems of assessing chemical risk. In accordance to this the European Commission (EC) Regulation No 1272/2008 became effective in January 2009. A new classification was implemented; Table 3.1 of Annex VI of the regulation lists the carcinogenic substances and their new classification.

Table 1 provides the precise definitions and some examples of each carcinogen category according to MAK Commission (3) and GHS.

The German Occupational Safety and Health Act

The German Occupational Safety and Health Act put the EU Directive on work health and safety into national legislation. It addresses the employer. The main item is workplace risk assessment. The assessment is to be done for each workplace in consideration of the individual resources and abilities of the respective workers at this workplace. The above mentioned technical rules and occupational exposure limits are the basis for the assessment and the decision on the necessity of risk reduction. Although workplace risk assessment is legally binding for every workplace, in a representative survey most workers (57%) denied the conduction of such risk assessment, 14% were unsure (4).

Main issue of occupational health and safety is primary prevention. Therefore risk reduction should be implemented as technical or operational measures first at all, only secondary as personal safety equipment. If despite protective measures a significant risk for the health of an employee remains, occupational medical examinations as secondary prevention measures are carried out by an occupational physician.

Occupational medical examinations

Occupational medical examinations are regulated in the German act on occupational medical prevention (Verordnung zur arbeitsmedizinischen Vorsorge, ArbMedVV). Some occupational medical examinations must be performed due to statutory requirements. In some cases employers are obliged to offer and employees are obliged to consent. In other cases employers are obliged to offer medical examinations, but the employees are free to decide whether to accept or not. Moreover in special situations employees themselves may request medical examinations due to their individual occupational risks. The decision about conducting a medical examination is to be based on an individual risk assessment. The DGUV has published recommendations for occupational medical examinations (5). They have legal status of guidelines for carrying out these examinations in order to evaluate individual risk and to advise employees. A list is given in Table 2.

These recommended examination schemes include suggested medical examinations, assessment criteria for long-term, short-term or no concerns regarding health (under certain conditions), and supplementary notes on external and internal exposure as well as on functional disorders. Their content has proven to be mostly helpful, and they are a good practical support for occupational physicians. The interval between examinations depends upon individual risk constellations and assumptions.

The ArbMedVV defines continuing surveillance by medical examinations which the employer has to conduct after the employee had stopped hazardous exposure. Additionally, the employer may delegate his duty to four organizations which care for workers previously exposed to carcinogenic substances:

- "Gesundheitsvorsorge - GVS" for workers exposed to asbestos or ceramic fibers for at least three months (since 1984)
- "Organisationsdienst für nachgehende Untersuchungen - ODIN" for workers exposed to various chemical carcinogenic agents for at least three months (since 1984)
- "Zentrale Betreuungsstelle Wismut - ZeBWis" for workers exposed to ionizing radiation in uranium mines of former German Democratic Republic (since 1991)
- "Bergbaulicher Organisationsdienst für nachgehende Untersuchungen fibrogene Stäube - Bonfis" for miners exposed to fibrogenic mine dust (since 1997)

Table 1 - MAK Commission definitions of carcinogen categories (3)

Carcinogen category	Definition	Examples
MAK 1 (GHS-category 1A)	Substances that cause cancer in man and can be assumed to contribute to cancer risk. Epidemiological studies provide adequate evidence of a positive correlation between the exposure of humans and the occurrence of cancer. Limited epidemiological data can be substantiated by evidence that the substance causes cancer by a mode of action that is relevant to man.	Asbestos, benzene, beryllium, nickel, sidestream cigarette smoke
MAK 2 (GHS-category 1B)	Substances that are considered to be carcinogenic for man because sufficient data from long-term animal studies or limited evidence from animal studies substantiated by evidence from epidemiological studies indicate that they can contribute to cancer risk. Limited data from animal studies can be supported by evidence that the substance causes cancer by a mode of action that is relevant to man and by results of in vitro tests and short-term animal studies.	Bitumen, cobalt, diesel engine emissions, glass fibres (fibrous dust), lead, hydrazine
MAK 3 (GHS-category 2)	Substances that cause concern that they could be carcinogenic for man but cannot be assessed conclusively because of lack of data. The classification in Category 3 is provisional.	
3A	Substances for which the criteria for classification in C ategory 4 or 5 are fulfilled but for which the database is insufficient for the establishment of a MAK or BAT value.	Cresol, oleic acid, titanium dioxide, toluene-diisocyanate, turpentine
3B	Substances for which in vitro or animal studies have yielded evidence of carcinogenic effects that is not sufficient for classification of the substance in one of the other categories. Further studies are required before a final decision can be made. A MAK or BAT value can be established provided no genotoxic effects have been detected.	Acrolein, carbon black, iron oxides, mercury, phenol
MAK 4	Substances with carcinogenic potential for which a non-genotoxic mode of action is of prime importance and genotoxic effects play no or at most a minor part provided the MAK and BAT values are observed. Under these conditions no contribution to human cancer risk is expected. The classification is supported especially by evidence that, for example, increases in cellular proliferation, inhibition of apoptosis or disturbances in cellular differentiation are important in the mode of action. The classification and the MAK and BAT values take into consideration the manifold mechanisms contributing to carcinogenesis and their characteristic dose-time response relationships.	Formaldehyde, hydrogen peroxide, sulfuric acid, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrahydrofuran, gamma-HCH
MAK 5	Substances with carcinogenic and genotoxic effects which are considered to contribute very slightly to human cancer risk, provided the MAK and BAT values are observed. The classification and the MAK and BAT values are supported by information on the mode of action, dose-dependence and toxicokinetic data pertinent to species comparison.	Acetaldehyde, ethanol, isoprene, styrene

Table 2 - List of recommendations for occupational medical examinations (5).

1.1	Mineral dust, Part 1: Respirable crystalline silica dust
1.2	Mineral dust, Part 2: Dust containing asbestos fibres
1.3	Mineral dust, Part 3: Man-made mineral fibres (aluminium silicate wool)
1.4	Exposure to dust (in general)
2	Lead and lead compounds (with the exception of alkyllead compounds)
3	Alkyllead compounds
4	Substances which cause skin cancer or skin alterations which tend to become cancerous
5	Ethylene glycol dinitrate and glycerol trinitrate
6	Carbon disulphide
7	Carbon monoxide
8	Benzene
9	Mercury and mercury compounds
10	Methanol
11	Hydrogen sulphide
12	Phosphorous (white, yellow)
14	Trichloroethene (trichloroethylene) and other chlorinated hydrocarbon solvents
15	Chromium (VI) compounds
16	Arsenic and arsenic compounds (with the exception of arsine)
19	Dimethylformamide
20	Noise
21	Cold working conditions
22	Teeth damage due to exposure to acids
23	Obstructive airway disorders
24	Skin disorders (not including skin cancer)
25	Driving, controlling and monitoring work
26	Respiratory protective equipment
27	Isocyanates
29	Benzene homologues (toluene, xylene isomers)
30	Hot working conditions
31	Hyperbaric pressure
32	Cadmium and cadmium compounds
33	Aromatic nitro and amino compounds
34	Fluorine and its inorganic compounds
35	Work abroad under exceptional climatic conditions and with other health risks
36	Vinyl chloride
37	VDU (video display unit) workplaces
38	Nickel and nickel compounds
39	Welding fumes
40	Carcinogenic and mutagenic substances
41	Work involving a danger of falling
42	Activities with a risk of infection
44	Hardwood dust
45	Styrene
46	Strain on the musculoskeletal system (including vibration)

Explanatory note: No. 13, 17, 18, 28 and 43 are missing issues due to deletion of historic investigations

Occupational diseases

Occupational diseases are defined as diseases which have been designated as occupational diseases by the Federal Government with consent of the Bundesrat, and which the insurants suffer from as the result of their insurance-covered occupation.

The German BKV is an ordinance of the Federal Government. It contains the list of recognized occupational diseases and regulates the procedure of occupational disease recognition. An occupational cause may be recognized if listed in the occupational disease list and if the person has been exposed accordingly. Diseases that are not on the list are therefore generally not recognized as occupational diseases. The list of occupational diseases is updated from time to time. A group of independent medical experts including epidemiologists supports the Ministry of Labour regarding which diseases should be added to the list. The scientific background and rationale for new occupational diseases is published in the German Ministerial Gazette and is available online in German (www.baua.bund.de). Some diseases, by legal definition, require the "discontinuation of all activities that caused or could cause the development, worsening or recurrence of the disease". The current list, valid since 2009, is provided in the appendix (6).

In addition to the contents of this list, a disease must also be recognized and compensated as an occupational disease, if, after new conclusions of the medical sciences, all other requirements of the definition of an occupational disease are already fulfilled, but the disease has not yet been enumerated in the list of occupational diseases. Only in some rare instances an escape clause might be effective, but requires scientific evidence on a very high level for acknowledgement.

The individual occupational disease procedure consists of three steps: notification, recognition and compensation.

Notification: if a physician or dentist has the "funded suspicion" that a disease could be of occupational origin in the aforementioned sense, he or she is obliged to file a *report* (Berufskrankheitenanzeige) to the statutory accident insurance or medical trade control or state occupational physician (Gewerbearzt). Beyond that the employee, the employer or the health insurance can initiate an occupational disease procedure.

Investigations concerning exposures at the workplace are almost exclusively performed by technical staff of the supervisory services of the trade association statutory accident insurance. In addition clearing centers from DGUV have been established and provide expertise for exposure quantification i. e. for asbestos, PAH and benzene.

In a standardized declaratory procedure, the extent to which juridical and medical requirements for the recognition of an occupational disease are met is checked by the statutory accident insurance. Frequently, a medical expert assessor is involved. Whereas exposure and disease must be proven "without reasonable doubt", the relationship between exposure and disease only requires "probability" to affirm occupational disease.

Recognition: finally, the "pension board" (employers' and employees' representatives) of the statutory accident insurance decides whether or not a disease is accepted to have an occupational etiology. Recommendations for peer assessment have been published for occupational lung diseases (Falkensteiner Empfehlung, Bochumer Emp-fehlung, Reichenhaller Empfehlung), noise induced hearing loss (Königsteiner Empfehlung) and dermal diseases (Bamberger Empfehlung). One out of four suspected (notified) cases is formally recognized as occupational disease. Usually the time period between notification and recognition does not exceed one year.

Compensation: after recognition, statutory accident insurances (statutory employers' liability insurance) pay for treatment, medical care, rehabilitation, educational measurements for occupational recommencement, disability pension, and, if appropriate, dependent's pension. Statutory accident insurance also covers measures to alleviate the consequences of the disease or to avoid impairment. If the disease reduces earning capacity by 20% or more, this is also covered by a pension. The extent of reduction of earning capacity depends on the degree of functional impairment caused by the occupational disease. In principle, these benefits are similar to those received subsequent to work or commuting accidents.

If recognition is denied or a compensation claim is rejected, patients can file an opposition. If this is still refused, the patient may take legal action. The court at the first level of jurisdiction is free of charge for the claimant. Second, and, in cases of general importance, third levels of jurisdiction can be invoked. In these cases, most judges involve independent medical expert witnesses, but rather infrequently independent technical expertise other than that of the defendant (accident insurance).

The workers have the right to enter the opposition and propose a trusted expert by themselves.

Occupational disease statistics

Statistical data are available as reports directly from the BAuA (7) and DGUV, or via the German Information System of the Federal Health Monitoring (Gesundheitsberichterstattung des Bundes, GBE) (8) and the Federal Statistical Office (Statistisches Bundesamt, DESTATIS) (9).

Official statistics of occupational diseases distinguish between numbers of suspected (notified), recognized and compensated cases.

In 2010 73.425 cases have been notified based on a suspicion on the existence of an occupational disease, 14.612 occupational diseases including 2.144 cancer cases have been accepted, of which 5.944 have been compensated; 2.486 people died due to accidents and occupational diseases, a majority (55%) of 1.385 cases died due to cancer (www.gbe-bund) (10); 2 of all suspected cases were finally defined as recognized, with 39% of the latter receiving compensation. The most frequently suspected and recognized occupational diseases are given in Fig. 1. Huge differences between high numbers of suspected and notified and low numbers of recognized cases are mainly due to the following facts:

- in some occupational diseases (particularly for skin and obstructive airway diseases) a cessation of causative exposure is required. The occupational disease won't be recognized due to formal reasons as long as this criterion is not fulfilled.
- intensity of occupational exposure is not sufficient or disease characteristics are not harmonious with occupational disease origin (e.g. in spinal disk diseases).

Fig. 2 shows recognized and newly compensated diseases in 2009. With noise-induced hearing loss, compensation is restricted to cases with very severe impairment. Regarding asbestos-induced disease, the gap is mainly due to many patients with isolated pleural plaques without functional impairment. In patients with malignant occupational diseases, such as mesothelioma or asbestos-induced lung and laryngeal cancer compensation rates are high.

Occupational cancer statistics

Mainly malignancies of the lung and pleura, bladder, blood cells and skin are recognized as occu-

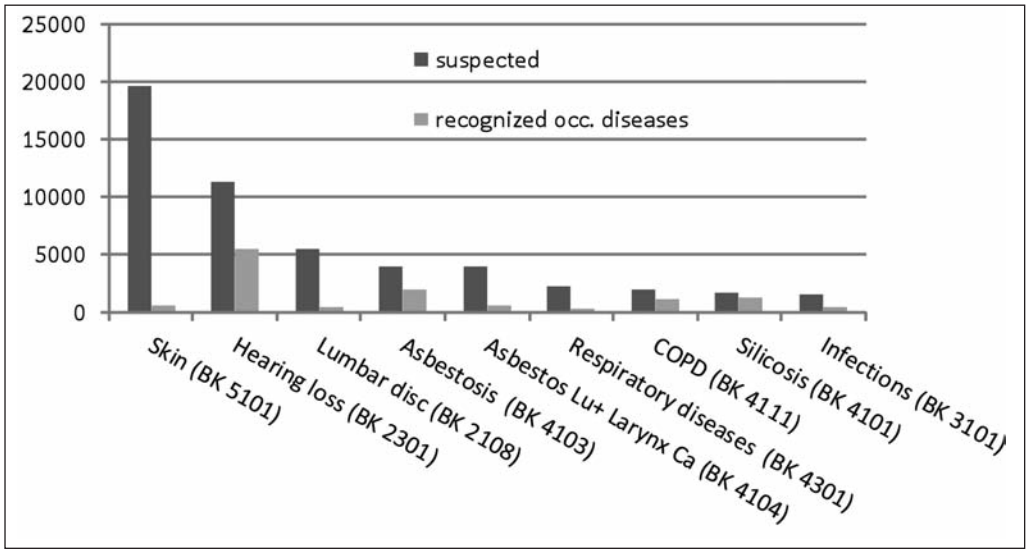

Fig. 1. Suspected and recognized occupational diseases in Germany in 2009 [BAuA 2011]

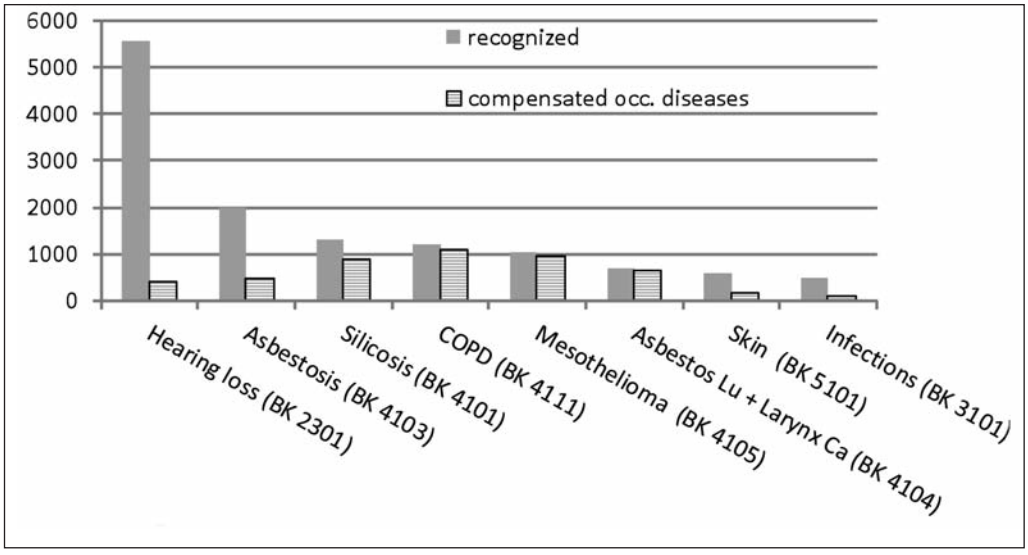

Fig. 2. Recognized and newly compensated occupational diseases in Germany in 2009 (7-9)

pational diseases. Specific work related causes for cancer of the respiratory tract are gases (such as radon), dusts (such as wood or quartz) critical fibers (such as asbestos) and chemicals (such as chromium VI and PAH).

Some of the occupational "disease numbers" (BK-Nr) in the national list comprise malignant and non-malignant diseases, so that no definite distinction is possible. Whereas in occupational diseases due to asbestos the numbers clearly distinguish occupational disease from occupational cancer BK 4103: benign asbestos-related diseases; BK 4104: occupational lung or larynx cancer; BK 4105: mesothelioma. This distinction is not made for most carcinogens at the workplace, i.e. arsenic, chromium, cadmium, aromatic amines and others. Former differences before re-unifications of East and West Germany of occupational cancers liable to compensation have been reviewed by Brüske-Hohlfeld (11).

Based on a recent specific evaluation of cancer cases, Table 3 summarizes which occupational cancers have been recognized during the period of 1978 to 2010 (10, 12). From this table, it is obvious that asbestos-induced malignancies dominate the occupational cancer spectrum, followed by ionizing radiation, aromatic amines, wood dust, benzene, and others. This situation has not much changed during recent years.

Within a total of 16.657 (100%) accepted occupational diseases in 2009, occupational cancers were mainly related to asbestos (BK 4104 + 4105) being the main single cause with 5.487 notified and 1.748 (10,5%) recognized cases, followed by BK 1301: aromatic amines with 168; BK 2402: ionizing radiation with 125; 1303: benzene with 124, and BK 4203: hardwood dust with 40 cases respectively.

Since 1978 until 2010 40.555 cases of occupational cancer in total have been recognized. Comparing the time trend from 1995 until 2008 of the data from the commercial trade and industrial statutory accident insurances (BK-DOK 2011) (8), increasing, unchanging and also decreasing incidences may be seen for different occupational cancers and diseases (Fig. 3-5). The mentioned lack of clear discrimination of cancer cases and the change of inclusion criteria (i.e. implementation of the criteria "25 asbestos fiber years" to BK 4104) in 1992 must be kept in mind.

Asbestos-related occupational diseases, summarizing asbestosis, lung cancer, laryngeal cancer and mesothelioma occur mainly in male workers (Fig. 3).

The time trend (Fig. 4) for occupational lung and larynx cancers depicts a plateau (BK 4104) but for mesothelioma (BK 4105) figures are still rising with a linear trend since 1985. Due to the long latency period the peak has not yet been reached, which has been predicted to occur around 2017 (13).

The abrupt rise of accepted cancer incidences due to benzene (Fig. 5) is caused by the new benzene associated BK 1318, becoming effective in 2009 and including the possibility to accept non-Hodgkin lymphomas (NHLs) and myeloproliferative diseases as benzene induced besides leukemia and toxic bone marrow diseases.

Table 3 - Occupational cancers recognized in Germany from 1978 to 2010 and 2009 to 2010 (12)

Disease denomination according to German list of occupational diseases (OD)	OD-Nr. (BK-Nr.)	Cancer Site	Cases of recognized occupational cancers (1978-2010)
Lung or larynx cancer - combined with asbestosis - combined with diseases of the pleura caused by asbestos dust or - if there is evidence of cumulative exposure to asbestos dust in the workplace of at least 25 fibre years {25 x 10^6 [(fibre/m^3) x years]}	4104	Lung, larynx	15.079
Mesothelioma of the pleura, the peritoneum or the pericardium caused by asbestos	4105	Pleura, peritoneum, pericardium	15.192
Diseases caused by ionizing radiation	2402	Lung, blood (leukaemia), rarely other extra-pulmonary sites	4.178
Mucosal changes, cancer or other neoplasms of the urinary tract caused by aromatic amines	1301	Urinary tract	1.945
Adenocarcinoma of the nasal cavaties and sinuses caused by oak or beech wood dust	4203	Inner nose	785
Diseases caused by benzene and its homologues or by styrene; diseases of the blood, the haematopoietic and lymphatic systems caused by benzene (2009-2010)	1303 + 1318	Leukaemias, non-Hodgkin lymphomas, refractory anaemias, myeloproliferative diseases	887
Silicosis; silicosis combined with active pulmonary tuberculosis (silicotuberculosis); lung cancer caused by silica dust where there is an accompanying silicosis or silicotuberculosis	4101, 4102 +4112	Lung; lung e.g. with silicotic scar	898
Malignant neoplasms of the respiratory tract and the lung caused by crude coke oven gas	4110	Lung, larynx	395
Diseases caused by chromium or its compounds	1103	Lung, nose	313
Skin cancer or skin alterations showing a cancerous tendency caused by soot, raw paraffin, tar, anthracene, pitch tar or similar substances	5102	Skin	292
Diseases caused by halogenated alkyl oxide, aryl oxide or alkyl aryl oxide	1310	Lung	292
Malignant neoplasms of the respiratory tract and the lung caused by nickel or its compounds	4109	Airways (lung, inner nose)	149
Diseases caused by arsenic or its compounds	1108	Lung, skin	142
Diseases caused by halogenated hydrocarbons	1302	Liver (hemangioendothelio-sarkoma), lung, kidney	119
Diseases caused by cadmium or its compounds	1104	Lung, kidney	n=?

Table 3 ***(continued)*** **-** Occupational cancers recognized in Germany from 1978 to 2010 and 2009 to 2010 (12)

Disease denomination according to German list of occupational diseases (OD)	OD-Nr. (BK-Nr.)	Cancer Site	Cases of recognized occupational cancers (1978-2010)
Diseases caused by beryllium or its compounds	1110	Lung	n=?
Diseases caused by halogenated alkyl oxide, aryl oxide or alkyl aryl sulphides	1311	Lung, stomach	n=?
Infectious diseases in cases where the insured person worked in health care, welfare or laboratories or was particularly exposed to a similar risk of infection in the context of another activity	3101	Lung (scars), liver (following infectious hepatitis)	n=?
Lung cancer caused by PAH if there is evidence of exposure to a cumulative dose of at least 100 benzo[a]pyrene years [(μg/m3) x years]	4113	Lung	13 (2009-2010)
Lung cancer caused by the interaction of asbestos dust and PAH, by evidence of exposure of a cumulative dose, which equates a probability of causation of 50% minimum, according to annex No. 2	4114	Lung	19 (2009-2010)

Explanatory note: ? = no differentiation of cancer and benign diseases available

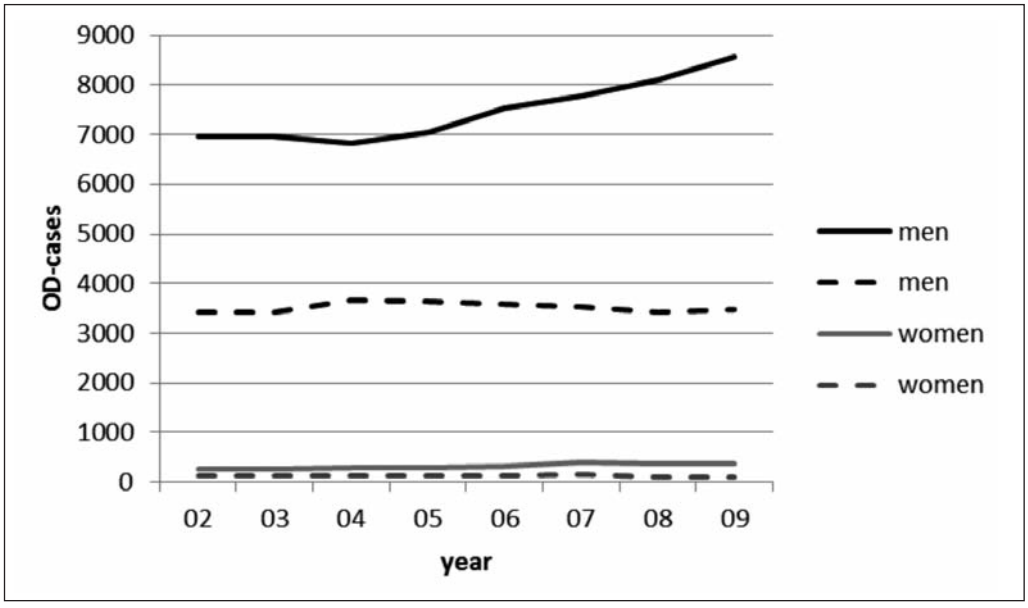

Fig. 3. Time trend incident cases of notified (straight line) and accepted (dotted line) asbestos-related occupational diseases (BK 4103-4105) in Germany from 2002 until 2009 (7-9)

Current issues on major occupational carcinogens

Cancer cases represent a growing part of occupational diseases in Germany, causing more than half of the deaths of recognized occupational diseases and exceeding three times the number of fatal accidents. The rising incidence of occupational cancers is mainly caused by former exposure to asbestos and radon (former uranium miners at the Wismut AG).

Asbestos

The asbestos cancer connection was postulated in Germany for the first time probably in the late 1930s: 11 cancer cases were presented by Nordmann

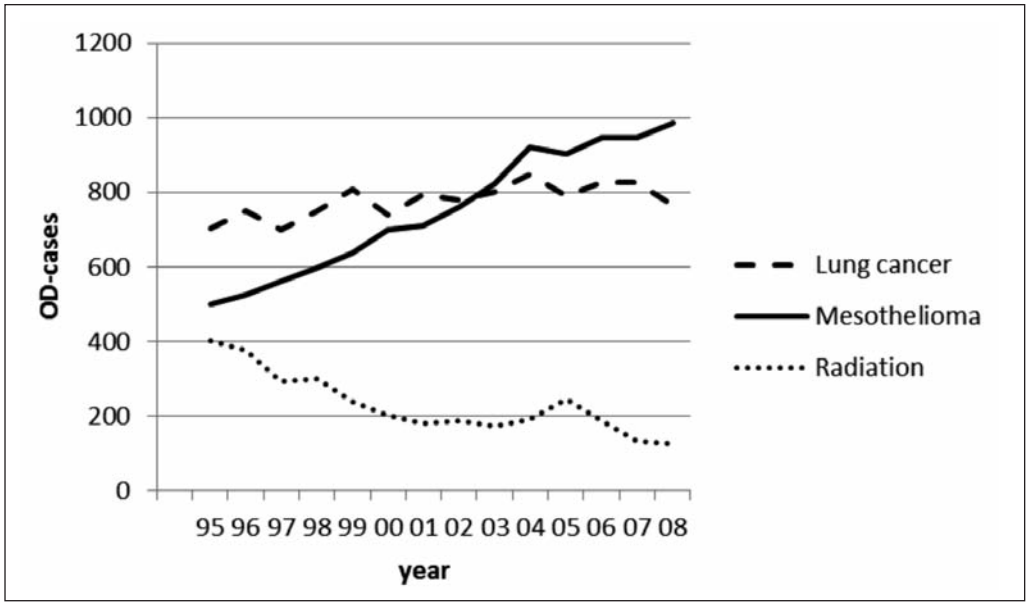

Fig. 4. Time trend of accepted incident cases of asbestos-related lung or larynx cancer (BK 4104), mesothelioma (BK 4105) and radiation induced occupational disease (BK 2402) in Germany from 1995 until 2008 (7-9)

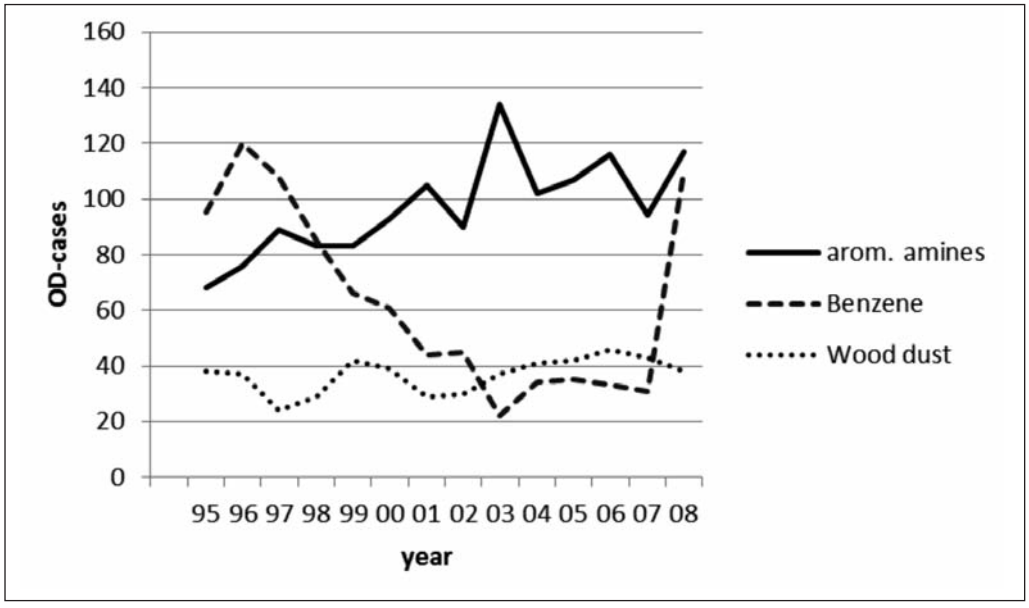

Fig. 5. Time trend of accepted incident cases of induced occupational diseases related to aromatic amines, benzene and wood dust in Germany from 1995 until 2008 (7-9)

at the VII International Conference on Occupational Accidents and Diseases in Frankfurt (14). In the first ordinance, lung diseases caused by silica dust or asbestos were not listed. In the third ordinance of the statutory occupational diseases (1936) coverage of accident insurance included "severe asbestos lung disease" (asbestosis) and in 1943, asbestosis in connection with lung cancer were added to the list of occupational diseases subject to compensation. Only 17 cases of asbestosis were reported in 1950 and only five cases were compensated. In 1952, recognition requirements for asbestosis were made easier and in 1976 the list included asbestosis, lung cancer and asbestosis, asbestos mesothelioma of the pleura and peritoneum and later in 1992 mesothelioma of the pericardium was added and in 1997 laryngeal cancer. The fiber model was introduced in 1992, making it possible to recognize asbestos related cancer if no pleural or parenchymal asbestos induced abnormalities were present, if exposure to a cumulative dose of at least 25 fiber-years (25 x 10^6 [fibers/m^3] x years) could be proven. Notably, the fiber-year model led to an increase in reported cases of lung and pleura-cancer from 831 (1992) to 1.331 (1994) and almost tripled in 1999 (2.420), with no end in sight (15). The amount of tobacco abuse is not

relevant in the procedure for recognition of lung cancer caused by asbestos.

In Germany, mainly the group of H.-J. Woitowitz, former head of the Institute of Occupational Medicine at Giessen University, shaped both the research and social medicine scenario regarding asbestos-induced diseases. Due to his personal efforts, the ban on asbestos in Germany was enforced already in 1993, thus 12 years before the EU followed with considerable delay in 2005. This simply means primary prevention for about 20.000 patients in Germany who were not taken ill – and did not die – from lung cancer or mesothelioma.

The discussion about an adequate histological diagnosis of asbestosis was clarified by the Helsinki criteria in 1997. In addition to confirmation of asbestos bodies in the lung parenchyma the detection of uncoated fiber burden is considered as sufficient to diagnose a fibrosis of lung parenchyma as asbestosis.

A recently published scientific guideline (16) and recommendations for compensation (17) will probably lead to more homogeneity between compensation cases.

Ionizing radiation, Cancer in uranium mining

Besides asbestos, the second most important carcinogenic occupational exposure was uranium mining (Wismut) in the former German Democratic Republic (GDR). The GDR was the third largest uranium producer in the world, and miners were exposed to high concentrations of radon.

After the Second World War large-scale exploitation of uranium ore deposits was started, first by the Soviet company under the code name of bismuth, and later by the "Soviet-German joint-stock company (SDAG) Wismut". Working conditions were poor and radiation exposure of workers high because pits were only "naturally" ventilated and it was drilled with high dust levels. The total work force has been estimated to be half a million, of which 300,000-400,000 worked underground, the latter heavily exposed to ionizing radiation (radon gas), but also to quartz dust, arsenic and asbestos. Since 1925, "Schneeberger lung disease" has been listed in Germany as an entity of occupational disease. However in the GDR, reporting of occupational diseases was established only after 1970, and the annual reports were classified as confidential. Until 1990 since when uranium mining was aborted, 31.325 occupational diseases have been acknowledged, 14.531 cases of silicosis and 5.492 radiation induced bronchial cancers. Between 1991 and 2009, 19.185 claims were filed with 7.638 accepted cases added, mainly radiation induced (BK 2402) with a peak of 708 cases in 1996 compared to 147 cases in 2009 (18).

Because of the long delay in the development of cancer, nowadays still many ex-employees of Wismut develop occupational cancers. For the large number of applications, a simplified procedure for the recognition of lung cancer as an occupational disease for former miners of the Wismut has been established (19-23).

Aromatic amines

The third most important single cause of occupational cancer are aromatic amines (BK 1301), established as an occupational disease since 1937 with 115 cases in 2008 and a total of 1.945 cases since 1978.

Wood dust

Whereas IARC has classified wood dust in general to cause sinonasal cancer, specific occupational exposure to hard wood dust from oak and beech wood is a necessary prerequisite for recognition of an occupational cancer in Germany (BK 4203) with 785 cases in total recognized.

Benzene

Whereas neurotoxic effects and cytopenic bone marrow depression (leucopenia, anemia, lymphopenia) as well as benzene-induced leukaemia have been compensated according to the list of occupational diseases since 1964, only recently (2009) NHLs were explicitly added and the system of recognizable and compensable diseases due to benzenes was re-organized.

The central scientific argument for considering NHLs as inducible by benzene and therefore recognizable as an occupational disease was that among cohorts with an increased incidence of acute myeloid leukaemia and acute nonlymphatic leukaemia (as

"classical" benzene-induced malignancies), NALs were also observed with an increased incidence (24). Thus exposure to benzene can be related to all cancers of the blood and lymphatic system including new developing blood cells (BK 1318). The scientific rationale also contains recommendations for peer assessment (25).

Discussion

The dual German occupational health system is rather complex, with several legal bodies and regulations and is therefore described in detail. Main stakeholders are federal and state ministries, state agencies, statutory accident insurances and their institutes and academia. This situation has arisen out of history and it remains doubtful if the advantage of mutual control outbalances the disadvantages caused by complexity.

Cancer cases represent an important part of occupational diseases in Germany, causing more than half of the deaths of recognized occupational diseases and exceeding three times the number of fatal accidents; 17% of accepted occupational diseases are occupational cancers. About 16 types of cancers may be attributed and recognized as occupational disease.

German cancer incidence data for notified and recognized cases are influenced by the (careless) exposure history, the latency period of the individual cancer, new scientific data, the change in legislation and reporting. The epidemiological presentation of the German data is clearly unsatisfactory. The current system of documentation of occupational diseases in Germany is confined to listed occupational diseases (Berufskrankheit, BK) as shown in the annex. Whereas for some carcinogens occupational disease numbers clearly distinguish occupational disease from occupational cancer, this distinction is not made for most other carcinogens at the workplace like e.g. arsenic, chromium, cadmium, aromatic amines and others. Thus the fraction of cancers within the entity of the defined occupational disease is not readily available. The last specific evaluation and documentation of occupational cancers covers the period of 1978- 2003 (12) and has been recently updated including now cases until 2010 (10).

Numbers do not reflect true causal incidence but rather a country specific incidence, confounded by reporting sensitivity and the legal framework, which defines if a case can be formally accepted and recognized as occupational cancer or not.

Difficulties which hamper the recognition process are the many different industries and exposures and a lack of retrospective exposure data at many workplaces. Workers' compensation is still handled heterogeneously between expert witnesses, and, therefore, between different statutory accident insurances. Thus, a scientific consensus between experts is clearly warranted.

Two crucial issues must be considered regarding the criticized low number of accepted occupational cancers:

1) Considering that approximately 4% of all cancers have an occupational origin (26), and given a total incidence of 420.000 malignancies per year in Germany, approximately 17.000 occupational malignancies would be expected. However, less than 6.000 suspected cancer cases are reported (notified) and only a third are accepted. Using other recent estimates this discrepancy would become even larger (27).
2) Generally, difficulties in retrospective exposure assessment lead to denial of an occupational origin (28).

It is an established fact that occupational diseases are generally under-reported and this is also true for asbestos-related diseases (29, 30).

Asbestos was the main cause of accepted occupational cancers in professions like building industry, metal, mechanical and technical workers, as well as in white collar workers (trade, service, office work, academia, administration). In the latter mesothelioma dominate asbestos related cancers by factor of nearly 3, whereas in the other professions - presumably with higher asbestos exposure - the ratio between mesothelioma and lung/larynx cancer varies between 0.7 and 1.3 (fig. 6). The mean ratio for Germany is 1. Current mesothelioma incidence in industrialized countries is considered to mirror past use of asbestos, the lung-cancer to mesothelioma ratio however varies between countries. Mesothelioma cases are generally accepted as being caused by asbestos, whereas asbestos-related lung cancers are clinically not distinguishable from those

due to other causes. Thus the criteria for recognition related to exposure (i.e. fiber-years) or diagnostic parameters (histology, pathology) have a strong influence upon the number of finally recognized lung cancer cases. The recognition procedures are specific to each country. Comparison of the incidence ratio of asbestos-related occupational diseases between different countries (29) gives a heterogeneous result (Fig. 7). According to McCormack *et al* (31) all types of asbestos fibers kill at least twice as many people through lung cancer than through mesothelioma, whereas Darnton *et al* (32) estimated the number of asbestos-related lung cancers between two-thirds and one death for every mesothelioma death, a ratio similar to Italy (33) and Scotland (34). A ratio of 0.7 was given for the Czech Republic, which is biased by under-reporting (35). Lung cancer in men has an incidence in Germany of about 60/100.000. Population attributable risk for lung cancer among males for definite asbestos exposure for Europe has been estimated to be 10% or more (36). Thus an incidence of 6 occupational lung cancers/1.000.000 workers could be related to asbestos, indicating for Germany and most other European countries considerable under-reporting.

To compare data on occupational diseases and occupational cancers between countries it is necessary to be aware of methodical differences

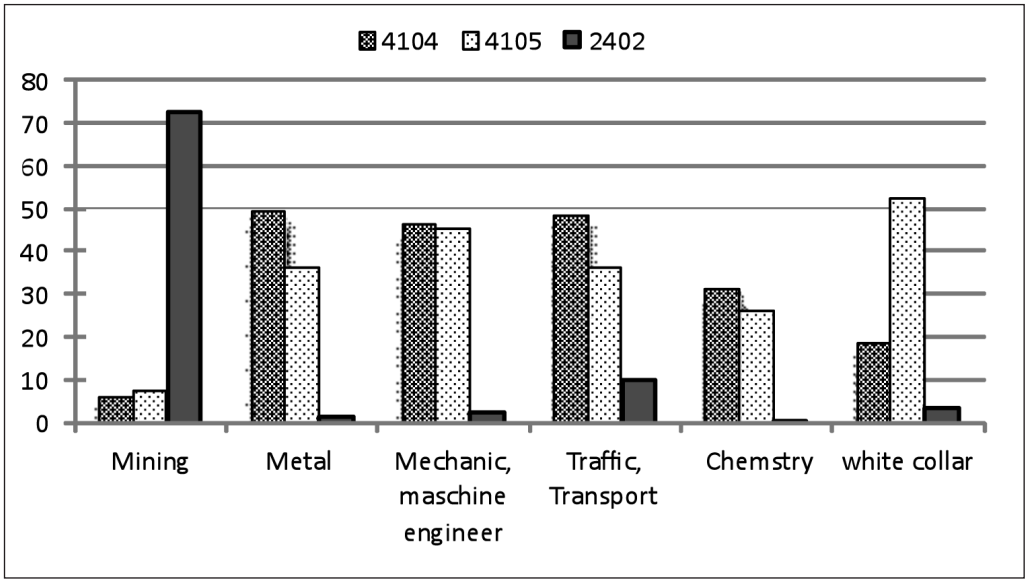

Fig. 6. Distribution of asbestos-related lung and larynx cancer (BK-4104), mesothelioma (4105) and ionizing radiation induced cancer (BK 2402) in different work areas in Germany (1987-2010, % of recognized occupational cancers) (10)

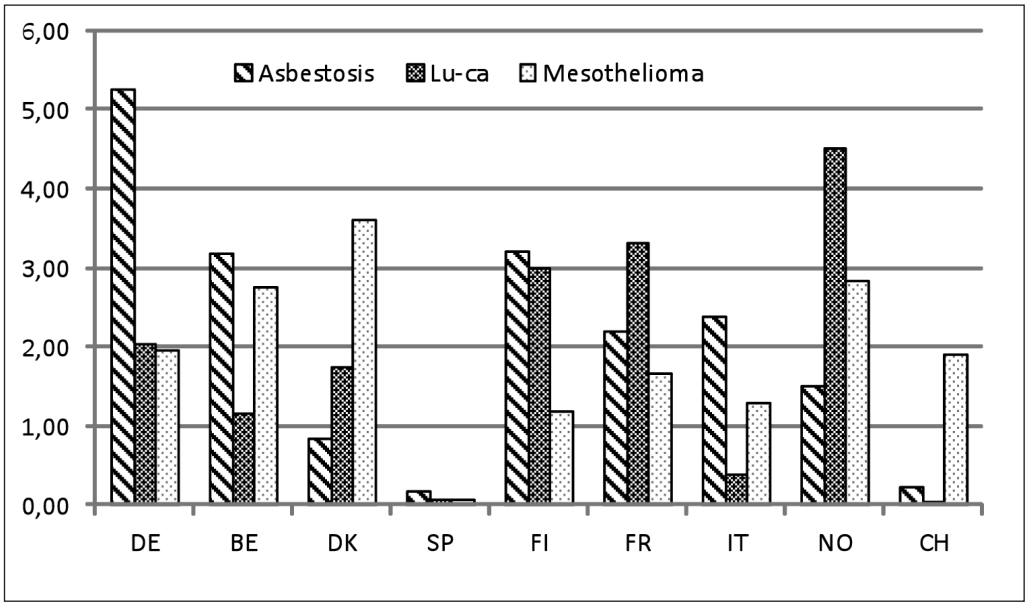

Fig. 7. Incidence ratio (cases per 100,000 people insured) of recognized asbestos-related occupational diseases in Europe in the year 2000 (29)

concerning legal procedures, reporting systems and data sources and quality with regard to recognition but also compensation of cases.

Occupational disease statistics are often complicated by lack of standardization, heterogeneous classification and coding, differences in notification, recognition and compensation, and last but not least reporting bias. This problem is illustrated in Fig. 7, showing striking differences between European countries for the incidence of asbestosis and asbestos related occupational cancers of the lung and larynx and mesothelioma (29). The same problem has been described for accidents and recognized occupational diseases in different countries respectively (37). This is most likely due to methodical differences in coding and reporting and recognition of occupational diseases rather than true incidences and must be judged as a major drawback when comparing data between countries. But also within a country serious limitations of occupational disease statistics exist.

Although the exact number of all cancer cases that are related to occupational influences will never be known, it must be assumed that the number of unreported cases is high. Under-reporting by physicians in hospital and private practice is a major drawback, even if a causal relationship is likely. The number and quality of the notifications depend upon the knowledge of the physician concerning occupational diseases as well as on the knowledge of the insured persons and their occupational histories.

The vast majority of occupational diseases and occupational cancers are preventable diseases. The still very high number of cases is mainly a legacy of the past, for which already primary prevention has been implemented by a ban on asbestos in 1993 and cessation of uranium mining; for the other cancers however surveillance, early detection and most importantly primary preventive measures must be strengthened. The change of paradigm by introducing a "traffic light model" for exposure to carcinogenic substances with a two-stage concept of acceptable and tolerable risk to differentiate measures to be taken may be seen as an improvement to reduce exposure on a transparent risk based rationale rather than technical feasibility, the weakness of the previous technical guidance concentration concept.

This approach has been introduced in the Netherlands already in 1993 (38). The "tolerable risk" (4:1.000) must not be exceeded by any means ("red traffic light"). In between ("yellow light") exposure reduction is still demanded (39).

Employers are forced to document the adequate reduction of exposure, and to equally set priorities based upon risk. This enables better works council participation and surveillance by supervising authorities to enforce minimization of exposure above the tolerable risk (39).

In the context of this lesson it is still deeply inhuman and cynical that there is no world-wide ban on asbestos. We can horrifyingly but easily foresee and anticipatorily calculate the number of patients dying from lung cancer and mesothelioma in emerging nations. World-wide 125 million workers are still exposed to asbestos dust. The International Labour Organization (ILO) estimates about 100.000 deaths due to asbestos world-wide annually. Given that these are totally avoidable, the responsibility of occupational medicine specialists demands strong "ceterum censeo" calls for a world-wide ban.

The current German system collects only data on about 16 cancers that are listed and the population cancer registries do not collect information on occupational history. An extended population-occupation cancer register collecting occupational cancers and other cancers and capturing also the employment history would be useful to identify more complex and possibly combined causes of cancer that might prevail in certain professions and thus broaden the perspectives for primary prevention. This approach has been successfully applied in the Nordic Occupational Cancer Study (NOCCA) showing variation in risk across occupations with some consistent cluster with high risk of numerous cancer types in men and also clusters of occupations with generally low cancer risks in both men and women (40).

Recommendations

Knowledge of cancer risk according to occupation and life style is essential for formatting primary cancer prevention. A population-occupation cancer register should be implemented in Germany in the future.

A more standardized if not fully harmonized reporting and documentation system for occupa-

tional diseases across European countries is strongly recommended to avoid bias and to make most use of the data in terms of recognition and primary prevention of occupational disease and cancer.

Physicians must be more aware to comply with their responsibility to notify cases with suspicion on the existence of an occupational disease, to reduce the estimated high number of unreported cases. Quality assessment and improvement activities should be implemented.

The recently introduced shift from a technical towards a quantitative risk based workplace assessment for carcinogenic substances may be seen as promising change of paradigm, because the system is capable to force employers to minimize exposure to a controllable level. Right now its implementation in practice is only in the beginning. A great number of employers still do not acknowledge the importance of the mandatory risk assessment at their workplaces and therefore – this being of even more importance – are ignorant to implementation of measures reducing or eliminating of hazardous exposures.

It is recommended to combine the services of organizations which care for workers health previously exposed to carcinogenic substances in order to allow systematic evaluation, to draw conclusions for work place risk assessment, to actualize nationwide guidelines for suitable secondary prevention as well as to detect possible syncarcinogenesis of combined carcinogen exposures.

External quality assessment should be introduced to harmonize the practice of handling of occupational diseases in the social statutory insurance, because we still see workers' compensation heterogeneously handled.

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References

1. Deutsche Gesetzliche Unfallversicherung (DGUV). International limit values: Germany – AGW (2010) http://www.dguv.de/ifa/en/gestis/limit_values/pdf/ags.pdf.
2. Committee on Hazardous Substances (AGS). Guide for the quantification of cancer risk figures after exposure to carcinogenic hazardous substances for establishing limit values at the workplace. (BAuA), Dortmund; 2008.
3. Deutsche Forschunggsesellsschaft (DFG) List of MAK and BAT Values 2010: Maximun concentrations and biological values at the workplace. Report 45, Wiley, 2010.
4. Siefer A, Beermann B. Grundauswertung der BIBB/BAuA-Erwerbstätigenbefragung 2005/2006. mit den Schwerpunkten Arbeitsbedingungen, Arbeitsbelastungen und gesundheitliche Beschwerden. BAuA, Dortmund, 2010.
5. (DGUV). Guidelines for occupational medical examinations. Stuttgart: Gentner Verlag, 2007.
6. (BAuA) Bundesanstalt für Arbeitsschutz und Arbeitsmedizin. Occupational Diseases Ordinance (2009) http://www.baua.de/en/Topics-from-A-to-Z/Occupational-Diseases/pdf/Occupational-Diseases.pdf?_blob=publicationFile&v=3.
7. (BAuA) Report - safety and health at work. (2011) http://www.baua.de/de/Informationen-fuer-die-Praxis/Statistiken/Berufskrankheiten/Berufskrankheiten.html
8. (DGUV) BK-DOK - Dokumentation des Berufskrankheiten-Geschehens in Deutschland. http://www.gbe-bund.de/
9. (DESTATIS) FSO. https://www.destatis.de/DE/Startseite.html/
10. Butz M. Dokumentation des Berufskrankheiten-Geschehens in Deutschland. Eine Darstellung der im Zeitraum 1978 bis 2010 anerkannten Berufskrankheiten. 2012 http://publikationen.dguv.de/dguv/pdf/10002/berufl_krebs-07-14-06.pdf
11. Brüske-Hohlfeld I. Occupational cancer in Germany. Environ Health Perspect 1999; 107 Suppl 2: 253-8.
12. Butz M. Beruflich verursachte Krebserkrankungen - Dokumentation des Berufskrankheiten-Geschehens in Deutschland - eine Darstellung der im Zeitraum 1978 bis 2001 anerkannten Berufskrankheiten: Hauptverband der gewerblichen Berufsgenossenschaften; 2005.
13. Coenen W, Schenk H. Ermittlung differenzierter Vorsorgegruppen bei Asbestexponierten. Sankt Augustin: Hauptverband der gewerblichen Berufsgenossenschaften. 1991.
14. Welz A. Weitere Beobachtungen über den Berufskrebs der Asbestarbeiter, aus dem Pathologischen und Bakteriologischen Institut der Hauptstadt Hannover. AGG 1942; 11: 536.
15. Drechsel-Schlund C, Haupt B, Drexel G, *et al.* Asbestverursachte Berufskrankheiten in Deutschland - Entstehung und Prognose. 2002. http://www.dguv.de/inhalt/zahlen/documents/asbest.pdf
16. Baur X, Fisseler-Eckhoff A, Heger M, *et al*. Diagnostics and expert opinion of asbestos-induced occupational diseases. Pneumologie 2011; 65(3): e1-e47.

17. (DGUV) Empfehlung für die Begutachtung asbestbedingter Berufskrankheiten - Falkensteiner Empfehlung. Berlin, 2011. http://www.dguv.de/landesverbaende/de/medien/documents/falkensteinere.pdf
18. Otten H. Berufskrankheiten des Uranerzbergbaus in Deutschland-Update. ArbeitsmedSozialmedUmweltmed. 2011; Poster P22 51. Jahrestagung der DGAUM (46): 186.
19. Norporth K, Woitowitz HJ. Beruflich verursachte Tumoren. In: H.-J. Schmoll. K. Höffken, K. Possinger (editors), Kompendium Internistische Onkologie Springer Verlag; 2006.
20. Grosche B, Kreuzer M, Kreisheimer M, *et al*. Lung cancer risk among German male uranium miners: a cohort study, 1946-1998. Br J Cancer 2006; 95(9): 1280-7.
21. Kreuzer M, Grosche B, Schnelzer M, *et al*. Radon and risk of death from cancer and cardiovascular diseases in the German uranium miners cohort study: follow-up 1946-2003. Radiat Environ Biophys 2010; 49 (2): 177-85.
22. Kreuzer M, Schnelzer M, Tschense A, *et al*. Cohort profile: the German uranium miners cohort study (WISMUT cohort), 1946-2003. Int J Epidemiol 2010; 39 (4): 980-7.
23. Kreuzer M, Walsh L, Schnelzer M, *et al*. Radon and risk of extrapulmonary cancers: results of the German uranium miners' cohort study, 1960-2003. Br J Cancer 2008; 99 (11): 1946-53.
24. Woitowitz HJ, Thielmann HW, Norporth K, *et al*. Benzol als Ausnahmekanzerogen in der Prävention und seine gentoxischen Folgen: Toxikologische, arbeitsmedizinische und sozialmedizinische Aspekte Zbl Arbeitsmed 2003; 53: 126-50.
25. (BMAS) Bundesministerium für Arbeit und Soziales. Wissenschaftliche Begründung zur Berufskrankheit Nummer 1318: Erkrankungen des Blutes, des blutbildenden und des lymphatischen Systems durch Benzol. GMBI 2007; 49-51: 974ff.
26. Doll R. The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. J Natl Cancer Inst 1981; 66 (6): 1191-308.
27. Clapp RW, Jacobs MM, Loechler EL. Environmental and occupational causes of cancer: new evidence 2005-2007. Rev Environ Health 2008; 23 (1): 1-37.
28. Woitowitz H. Berufskrankheiten durch Kanzerogene: Nachweis oft nicht mehr möglich. Dtsch Ärztebl 2010; 107 (16): A-751.
29. Eurogip, 24-E. Asbestos-related occupational diseases in Europe. (2006) http://www.eurogip.fr/en/docs/EUROGIP-24E-AsbestosOccDiseases.pdf
30. Eurogip, 49-E. Work-related cancers: what recognition in Europe? (2010) http://www.eurogip.fr/en/docs/EUROGIP_RecoCancerspro_49E.pdf
31. McCormack V, Peto J, Byrnes G, *et al*. Estimating the asbestos-related lung cancer burden from mesothelioma mortality. Br J Cancer 2012; 106 (3): 575-84.
32. Darnton AJ, McElvenny DM, Hodgson JT. Estimating the number of asbestos-related lung cancer deaths in Great Britain from 1980 to 2000. Ann Occup Hyg 2006; 50 (1): 29-38.
33. Marinaccio A, Scarselli A, Binazzi A, *et al.* Magnitude of asbestos-related lung cancer mortality in Italy. Br J Cancer 2008; 99 (1): 173-5.
34. Watterson A, Gorman T, O'Neill R. Occupational cancer prevention in Scotland: a missing public health priority. Eur J Oncol 2008; 13 (3): 161-9.
35. Pelclova D, Fenclova Z, Urban P. Occupational Cancer in the Czech Republic –a tip of the iceberg? Eur J Oncol 2011; 16 (3): 161-9.
36. Albin M, Magnani C, Krstev S, *et al*. Asbestos and cancer: an overview of current trends in Europe. Environ Health Perspect 1999; 107 Suppl 2: 289-98.
37. (WHO) European health for all database. WHO Regional Office for Europe, Copenhagen, Denmark. 2011; http://data.euro.who.int/hfadb/
38. Brokamp H, Hendriks B. Risikobasiertes Grenzwertkonzept in den Niederlanden – Entwicklungen und Erfahrungen. Gefahrstoffe - Reinhaltung der Luft 2008; 68 (7/8): 317-20.
39. Wriedt H. Das Risikoakzeptanzkonzept für krebserzeugende Gefahrstoffe – Zwischenbilanz und Ausblick. Gefahrstoffe - Reinhaltung der Luft 2010; 70 (9): 351-5.
40. Kjaerheim K, Martinsen JI, Lynge E, *et al*. Effects of occupation on risks of avoidable cancers in the Nordic countries. Eur J Cancer. 2010; 46(14): 2545-54.

Appendix:
List of occupational diseases (BK) in Germany liable for compensation (6)

BK No. Diseases

1 Diseases caused by chemical agents

11 Metals and metalloids

1101 Diseases caused by lead or its compounds
1102 Diseases caused by mercury or its compounds
1103 Diseases caused by chromium or its compounds
1104 Diseases caused by cadmium or its compounds
1105 Diseases caused by manganese or its compounds
1106 Diseases caused by thallium or its compounds
1107 Diseases caused by vanadium or its compounds
1108 Diseases caused by arsenic or its compounds
1109 Diseases caused by phosphorus or its inorganic compounds
1110 Diseases caused by beryllium or its compounds

12 Asphyxiating gases

1201 Diseases caused by carbon monoxide
1202 Diseases caused by hydrogen sulphide

13 Solvents, pesticides and other chemical agents

1301 Mucosal changes, cancer or other neoplasms of the urinary tract caused by aromatic amines
1302 Diseases caused by halogenated hydrocarbons
1303 Diseases caused by benzene and its homologues or by styrene
1304 Diseases caused by nitro or amino compounds of benzene or its homologues or their derivatives
1305 Diseases caused by carbon disulphide
1306 Diseases caused by methyl alcohol (methanol)
1307 Diseases caused by organic phosphorus compounds
1308 Diseases caused by fluorine or its compounds
1309 Diseases caused by nitric acid esters
1310 Diseases caused by halogenated alkyl oxide, aryl oxide or alkyl aryl oxide
1311 Diseases caused by halogenated alkyl oxide, aryl oxide or alkyl aryl sulphides
1312 Dental diseases caused by acids
1313 Lesions to the cornea of the eye caused by benzoquinone
1314 Diseases caused by p-tert-butylphenol
1315 Diseases caused by isocyanates, which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
1316 Liver diseases caused by dimethyl formamide
1317 Polyneuropathy or encephalopathy caused by organic solvents or their mixtures
1318 **Diseases of the blood, the hematopoietic and lymphatic systems caused by benzene**

Re nos. 1101 to 1110, 1201 and 1202, 1303 to 1309 and 1315: Skin diseases are excluded. They are regarded as diseases within the meaning of this annex only if they are symptoms of a general disease which have been caused by the absorption of the harmful agents or which must be compensated pursuant to number 5101.

2 Diseases caused by physical impact

21 Mechanical impact

2101 Diseases of the tendon sheaths or diseases of the peritendinous tissue or of the insertions of tendons or muscles which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
2102 Meniscus lesions caused by excessive physical load on the knee joints either sustained or repeated over several years
2103 Diseases caused by vibration during work with pneumatic or similar tools or machines
2104 Circulatory disturbances of the hands caused by vibration, which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
2105 Chronic diseases of the mucous bursae caused by constant pressure
2106 Pressure-induced nerve damage

2107 Strain fracture of the spinous processes
2108 Disc-related diseases of the lumbar spine caused by the lifting or carrying of heavy loads over many years or by performance of work in an extremely bent posture over many years which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
2109 Disc-related diseases of the cervical spine caused by the carrying of heavy loads on the shoulder over many years which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
2110 Disc-related diseases of the lumbar spine caused by the predominately vertical impact of whole-body vibration in a seated position over many years which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
2111 Excessive dental abrasion caused by silica dust exposure over several years
2112 Osteoarthritis of the knee by occupational kneeling or comparable occupational load with a cumulative exposure of at least 13.000 hours and a minimum exposure time of one hour per shift

22 Compressed air

2201 Diseases caused by work in compressed air

23 Noise

2301 Hearing impairment caused by noise

24 Radiation

2401 Cataract caused by heat radiation
2402 Diseases caused by ionizing radiation

3 Diseases caused by infectious agents or parasites including tropical diseases

3101 Infectious diseases in cases where the insured person worked in health care, welfare or laboratories or was particularly exposed to a similar risk of infection in the context of another activity
3102 Diseases transmitted to humans by animals
3103 Miner's vermination caused by Ancylostoma duodenale or Strongyloides stercoralis
3104 Tropical diseases, typhus

4 Diseases of the respiratory tract, lungs, pleura and peritoneum

41 Diseases caused by inorganic dust

4101 Silicosis
4102 Silicosis combined with active pulmonary tuberculosis (silicotuberculosis)
4103 Asbestosis or diseases of the pleura caused by asbestos dust
4104 Lung or larynx cancer
- combined with asbestosis
- combined with diseases of the pleura caused by asbestos dust or
- if there is evidence of cumulative exposure to asbestos dust in the workplace of at least 25 fiber years {10E6 [(fiber/m^3) x years]

4105 Mesothelioma of the pleura, the peritoneum or the pericardium caused by asbestos
4106 Diseases of the lower respiratory tract and the lungs caused by aluminium or its compounds
4107 Pulmonary fibrosis caused by metallic powder present in the production or processing of hard metals
4108 Diseases of the lower respiratory tract and the lungs caused by dust from basic slag (Thomas phosphate)
4109 Malignant neoplasms of the respiratory tract and the lungs caused by nickel or its compounds
4110 Malignant neoplasms of the respiratory tract and the lungs caused by crude coke oven gas
4111 Chronic obstructive bronchitis or emphysema in underground hard coal miners if there is evidence of exposure to a cumulative dose of generally 100 fine dust years [(mg/m^3) x years]
4112 Lung cancer caused by silica dust where there is accompanying silicosis or silicotuberculosis
4113 Lung cancer caused by polycyclic aromatic hydrocarbons if there is evidence of exposure to a cumulative dose of at least 100 benzo[a]pyrene years [(µg/m3) x years)
4114 Lung cancer caused by the interaction of asbestos dust and polycyclic aromatic hydrocarbons, by evidence of exposure of a cumulative dose, which equates a probability of causation of 50 percent minimum, according to annex No. 2
4115 Pulmonary fibrosis caused by extreme exposure to welding fumes and welding gases over many years (siderofibrosis)

42 Diseases caused by organic dust
4201 Exogenic allergic alveolitis
4202 Diseases of the lower respiratory tract and the lungs caused by raw cotton, raw flax or raw hemp dust (byssinosis)
4203 Adenocarcinoma of the nasal cavaties and sinuses caused by oak or beech wood dust
43 Obstructive diseases of the respiratory tract
4301 Obstructive diseases of the respiratory tract (including rhinopathy) caused by allergic agents which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
4302 Obstructive diseases of the respiratory tract caused by chemical irritants or agents with a toxic effect which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
5 Skin diseases
5101 Severe or recurrent skin diseases which have forced the person to discontinue all activities that caused or could cause the development, worsening or recurrence of the disease
5102 Skin cancer or skin alterations showing a cancerous tendency caused by soot, raw paraffin, tar, anthracene, pitch or similar substances
6 Diseases caused by other factors
6101 Miner's nystagmus