

Article

Carcinogenic Chemicals in Occupational Settings: A Tool for Comparison and Translation between Different Classification Systems

Carolina Zellino ^{1,*}, Andrea Spinazze ¹ , Francesca Borghi ² , Davide Campagnolo ¹ , Giacomo Fanti ¹ , Marta Keller ¹, Alessio Carminati ¹, Sabrina Rovelli ¹ , Andrea Cattaneo ¹  and Domenico Maria Cavallo ¹

¹ Department of Science and High Technology, University of Insubria, 22100 Como, Italy; andrea.spinazze@uninsubria.it (A.S.); davide.campagnolo@uninsubria.it (D.C.); giacomo.fanti@uninsubria.it (G.F.); mkeller@uninsubria.it (M.K.); acarminati@uninsubria.it (A.C.); sabrina.rovelli@uninsubria.it (S.R.); andrea.cattaneo@uninsubria.it (A.C.); domenico.cavallo@uninsubria.it (D.M.C.)

² Department of Medical and Surgical Sciences, University of Bologna, 40138 Bologna, Italy; francesca.borghi12@unibo.it

* Correspondence: czellino@uninsubria.it; Tel.: +39-031-2386628

Abstract: In the European Union, Occupational Safety and Health legislation generally refers to European Regulation (CE) n. 1272/2008 to define and classify carcinogens of concern for occupational risk assessment and exposure assessment. In Europe, the current reference is Directive (UE) 2022/431, regarding carcinogen, mutagen, and reprotoxic agent (CMR) exposure. However, at the worldwide level, different classification approaches are used to establish carcinogenicity of substances and it is often difficult to compare the classifications of carcinogenicity (CoCs) proposed by different international bodies. This study aims to investigate a list of carcinogens of concern in occupational settings based on the CLP (Classification Labelling Packaging) CoC and to create a tool that allows a rapid translation–comparison of some international CoCs with the reference one. CoCs proposed by various sources were consulted and used to apply a translation method, to favor an alignment of different CoCs according to a reference. Results outlined that, considering diverse sources, CoCs can result in different classifications of the same chemicals. Overall, this may have implications for the hazard assessment process, which is the base of risk assessment. The proposed tool is expected to help risk assessors in the occupational field when it is needed to have a comparison with different CoC systems.

Keywords: chemical risk assessment; carcinogens; CMR; occupational exposure; classifications of carcinogenicity



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1. Introduction

1.1. Background

The European legislation on Occupational Safety and Health (OSH) usually refers to European Regulation (CE) n. 1272/2008 [1] (known as CLP—Classification Labelling Packaging) to define and classify carcinogenic chemical agents of concern for occupational risk assessment and occupational exposure assessment. The CLP Regulation, in turn, is aligned with the GHS (Global Harmonised System of chemical substance classification and labelling), the United Nations system to identify hazardous chemical substances and inform the customers–users regarding these hazards. Currently, at the European level, the most recent regulatory reference regarding the classification of carcinogenic chemical agents of occupational interest is the Directive (UE) 2022/431 [2], amending Directive 2004/37/EC [3], regarding the protection of workers from the risks related to exposure to carcinogen, mutagen, and reprotoxic agents (CMRs) at work. An example of practical

implementation of European legislation at the national level is the Italian OSH legislation [4] that defines a carcinogen chemical substance as “(1) a substance or mixture that matches the criteria for classification as a 1 A or 1 B carcinogen category in Annex I of the Regulation (CE) n. 1272/2008 of the European Parliament and Council”.

1.2. Problem Statement

At present, it is interesting to note how it is often difficult to compare the classifications of carcinogenicity (CoCs) proposed by different international bodies and agencies [5,6], especially when it is necessary to exploit such information for risk assessment (i.e., process for calculating or estimating (quantifying) the risk to a given organism, system, or group of people, including identification of the resulting uncertainties. The risk assessment process comprises four steps: hazard identification, hazard characterization, exposure assessment, and risk characterization, and risk management (i.e., process following risk assessment that consists of examining the results and developing strategies to govern it by taking appropriate measures (technical, organizational, procedural, communication, and training) for prevention and control) for occupational settings. Overall, there is not one homogeneous classification approach to establish carcinogenicity of substances and a hard debate exists on this topic. Boobis and co-workers [5,6] argued that the CoC is evaluated using the following: (i) “Outmoded” schemes based solely on hazard identification (such as those used by IARC—International Agency for Research on Cancer and UN GHS); (ii) Approaches based on hazard and risk characterization (such as those used by US EPA—Environmental Protection Agency and ACGIH—American Conference of Governmental Industrial Hygienist). Following what was discussed in the previous studies [5,6], in the first kind of scheme, chemicals are divided into carcinogens and non-carcinogens and the categorization can be placed into the same category cases despite widely differing potencies and modes of action. This process bypasses the hazard characterization and risk assessment phases, stepping from hazard identification to risk management (the IARC and GHS systems classify agents on the strength of evidence and the capability to cause cancer in humans but provide no guidance on the circumstances in which this could occur). In the second kind of approach, an integrated scheme allows us to make informed risk management decisions, because the hazard is evaluated in the context of dose, potency, and exposure. Based on this discussion, Boobis and colleagues [5,6] argued that a widely accepted, shared, and recognized methodology for carcinogens assessment and classification is needed, and the evaluation approach should incorporate principles and concepts of existing international consensus-based frameworks including the WHO IPCS (World Health Organisation—International Programme on Chemical Safety) mode-of-action framework. This proposal was critically discussed, and some authors [5] argued that this approach is largely silent on the important role of epidemiological data, while key methodological aspects do not reflect the current state of science. The scientific hazard assessment is inappropriately conflated with the broader socio-political process of risk management, in sharp contrast to prominent recommendations for advancing risk assessment and systematic review. The review article of Felter and colleagues [7] summarizes themes and discussions resulting from an expert workshop on the scientific limitations of the current binary carcinogenicity classification scheme and the tiered testing strategies founded on new approach methodologies. This concept is reiterated by the article of Doe and colleagues [8,9], where a new-approach cancer classification scheme has been proposed. As highlighted by this discussion, there is not a unique and homogeneous classification approach to assess and classify the carcinogenicity of chemicals. In occupational chemical risk assessment, the possibility of having CoCs for chemicals of interest obtained using different systems can cause uncertainty, misunderstanding, or confusion in the definition of the risk assessment and risk management. On the contrary, the possibility of having access to a harmonized system to compare different CoCs could enable a better understanding in the hazard identification phase and, thus, allow us to enhance the risk assessment process for carcinogenic chemicals.

1.3. Aim of the Study

The principal aim of this study is the implementation of a tool (based on an Excel spreadsheet) to allow a rapid comparison of the main international classification systems for a list of chemicals of concern for occupational carcinogenic risk. The intermediate steps necessary to achieve this result were the following: (i) To investigate a list of chemicals of concern for occupational carcinogenic risk, classified as carcinogens or suspected to be carcinogens based on the CLP Regulation; (ii) To search their CoC according to other international (i.e., non-EU) CoCs and convert them in the CLP CoC; (iii) To compare the reference CLP CoC with others.

2. Methods

Substances and compounds of concern due to their occupational carcinogenic risk, that have been classified as carcinogens or suspected to be carcinogens based on the CLP Regulation, have been selected for the study. Two of the authors (C.Z. and A.S.) selected a list of chemical agents and their respective CLP CoC from the list of harmonized entries in Annex VI of CLP (18th Adaptation of Technical Progress which will come into effect in November 2023 [10]). The ECHA tool “Simple search for chemicals/regulated substances” [11] was consulted too. Once the CoC was defined according to CLP, the international CoCs by IARC [12], US EPA [13], US NTP—National Toxicology Program [14], ACGIH [15], and NIOSH—National Institute for Occupational Safety and Health [16] were obtained for the same chemical agents. Chemicals’ classifications were searched using their specific CAS number (Chemical Abstract Service Registry Number) or, if CAS numbers were not available for certain chemicals, using their CLP ECHA name. The last search was performed in May 2023.

Once defined according to the selected sources, these CoCs were “converted” using the equivalent CLP CoC (arbitrarily considered to be the reference for this study) based on criteria defined in previous studies [17,18]. The scheme for the conversion of EPA, ACGIH, NTP, and IARC CoCs into the CLP CoC is summarized in Table 1; the entire methodology is summarized in Figure 1. All the classification systems were converted (translated) into the CLP CoC system to allow an intuitive comparison to them due to their different criteria of classification and their terminologies.

It is worth noting that, regarding the NIOSH classification, a “qualitative” carcinogenicity classification was attributed, based only on the presence or absence of the chemicals in the consulted list, as no other information on carcinogenicity level categorization is available. Therefore, the category “C” referring to the NIOSH CoC defines an “Occupational Carcinogen”. In addition, if the outcome of classification conversion resulted in an uncertain assignment between different classification categories (for example CLP categories 1B and 2) the classification was arbitrarily assigned to the most precautionary CLP category of the options considered (1B in this example). The concordance of the “converted CLP CoC” with the reference classification (“original CLP”) was verified. If the CLP CoC was not available (“n.a.”: not available; see Table S1—Supplementary Materials) for the selected chemicals, the IARC classification was considered as a primary reference for comparison with other classification systems. It is important to note that no new hazard assessments or new classifications of chemical agents were proposed or carried out in this study. Instead, the classification proposed by various sources consulted regarding the classification of carcinogenicity of selected chemicals was retrieved and used to apply a translation method, to favor an alignment of different classification systems according to a system chosen as a reference.

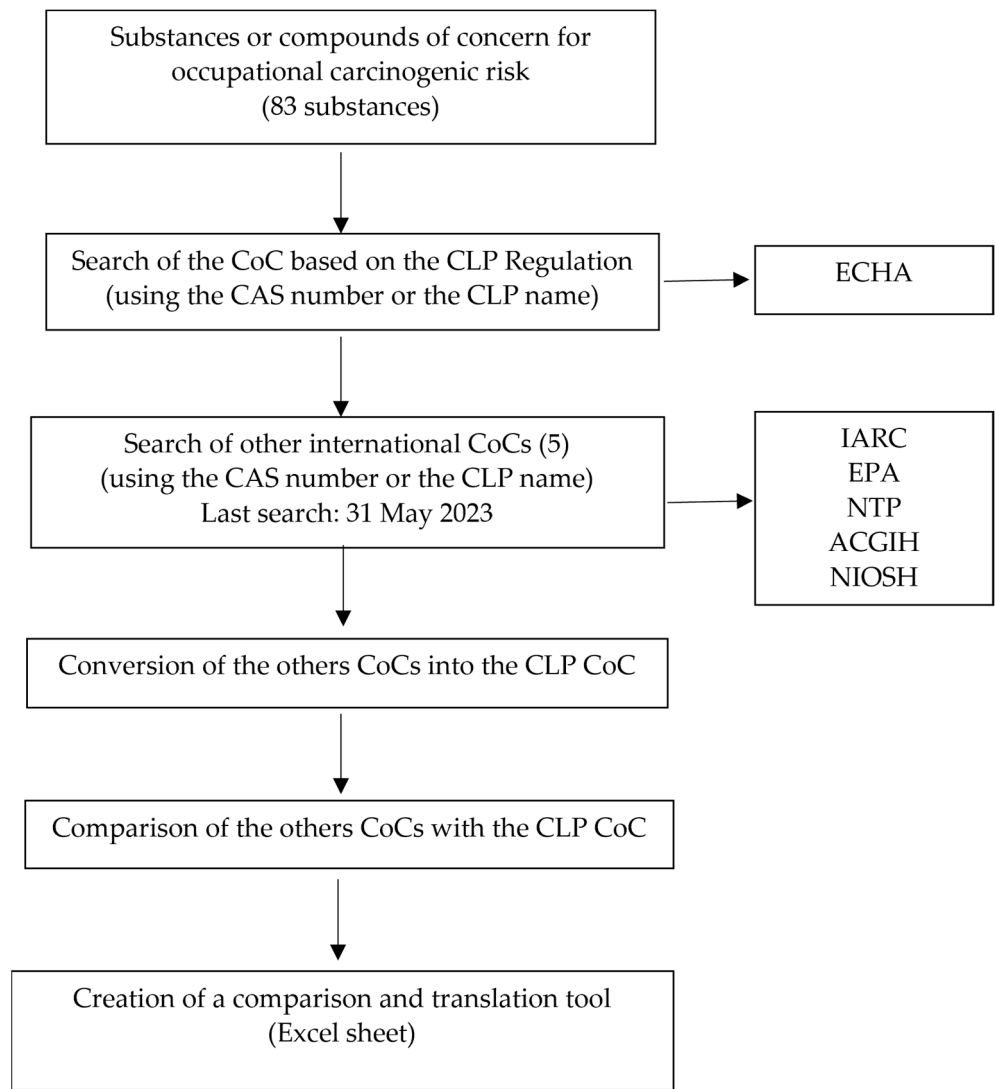


Figure 1. Summary scheme of the methodology adopted for the study.

Table 1. EPA, ACGIH, NTP, and IARC classification conversion into the reference CLP CoC and their comparison with the same. Regarding the EPA classification, the italic sentences refer to the actual classification (2005).

CLP	EPA (1986–2005)	ACGIH	NTP	IARC	NIOSH
1A Known to have carcinogenic potential for humans; classification is largely based on human evidence.	Group A Carcinogenic to Humans <i>Carcinogenic to Humans</i>	A1 Confirmed human carcinogen	Known To Be Human Carcinogens	1 Carcinogenic to humans	C Occupational Carcinogen
1B Presumed to have carcinogenic potential for humans; classification is largely based on animal evidence.	Group B Probably Carcinogenic to Humans Group B1: agents with sufficient evidence from animal bioassay data but limited human evidence. Group B2: little or no human data. <i>Likely to be Carcinogenic to Humans</i>	A2 Suspected human carcinogen	Reasonably Anticipated To Be Human Carcinogens	2A Probably carcinogenic to humans 2B * Possibly carcinogenic to humans	

Table 1. Cont.

CLP	EPA (1986–2005)	ACGIH	NTP	IARC	NIOSH
2 Suspected human carcinogens	Group C Possibly Carcinogenic to Humans <i>Suggestive Evidence of Carcinogenic Potential</i>	A3 Confirmed animal carcinogen with unknown relevance to humans	Reasonably Anticipated To Be Human Carcinogens	2B * Possibly carcinogenic to humans	

Note: **CLP**: Classification Labelling Packaging; **EPA**: Environmental Protection Agency (United States); **ACGIH**: American Conference of Governmental Industrial Hygienists (United States); **NTP**: National Toxicology Program (United States); **IARC**: International Agency for Research on Cancer; **NIOSH**: National Institute for Occupational Safety and Health (United States). * NIOSH will consider assigning the “GHS Carcinogen Category 1B: presumed human carcinogen” whenever the classifications that NIOSH reviews would not meet the criteria for GHS Category 1A, and any of the following conditions apply: IARC classifies the carcinogen as “Group 2A: probably carcinogenic to humans”, IARC classifies the carcinogen as “Group 2B: possibly carcinogenic to humans”, and sufficient evidence in animals supports the classification (according to IARC criteria). NIOSH will consider assigning “GHS Carcinogen Category 2: suspected carcinogen” whenever the classifications that NIOSH reviews would not meet the criteria for GHS Category 1A or 1B, and any of the following conditions apply: IARC classifies the carcinogen as “Group 2B: possibly carcinogenic to humans” and the evidence supporting that classification is limited in animals (according to IARC criteria).

3. Results

3.1. General Description of the Obtained Results

A total of 83 chemical substances, compounds, or mixtures of concern for occupational carcinogenic risk were selected for this study. A conversion and translation database (“tool” is used from here on out with the same meaning) has been created (Excel spreadsheet). The database is freely available online for consultation [19]. As mentioned, CLP, IARC, EPA, ACGIH, NTP, and NIOSH CoCs for the selected chemicals were retrieved from proper sources, and IARC, EPA, ACGIH, NTP, and NIOSH CoCs were converted into the CLP CoC. Details on the database structure, the conversion, and the comparison of substances are reported in the supplementary material (Tables S2–S4). Figure 2 reports comparison results of the international IARC, EPA, NTP, ACGIH, and NIOSH CoCs converted into the CLP CoC and compared with the original CLP CoC. It is worth noting that after the conversion some cases of indecision were found (this could be due to the fact that there is not always a unique and clear correspondence between different CoCs; see Table 1).

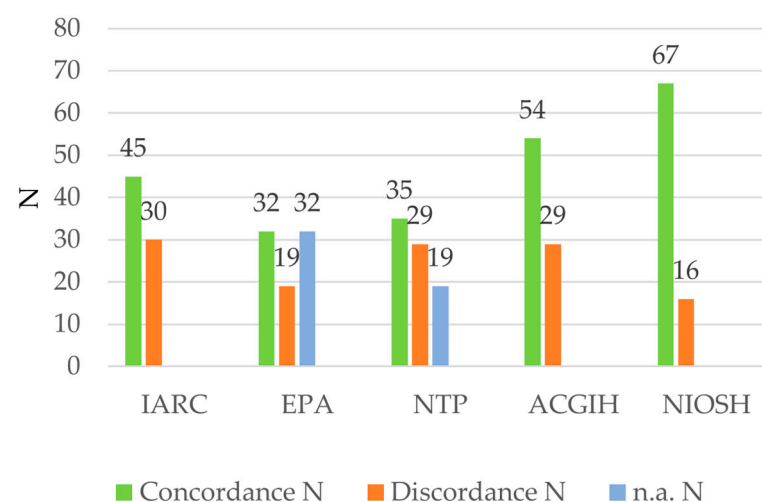


Figure 2. Comparison results of the international IARC, EPA, NTP, ACGIH, and NIOSH CoCs, converted into the CLP CoC and compared with the original CLP CoC. IARC: International Agency for Research on Cancer; EPA: Environmental Protection Agency (United States); NTP: National Toxicology Program (United States); ACGIH: American Conference of Governmental Industrial Hygienists (United States); NIOSH: National Institute for Occupational Safety and Health (United States); n.a.: not available.

The IARC CoC was used via arbitrary choice as a reference CoC for eight (10%) chemicals (namely, 2,3,7,8-tetrachlorodibenzo[b,e][1,4]dioxin (TCDD); polychlorobiphenyls (PCBs); benzoyl chloride; cyclopenta[c,d]pyrene; tungsten carbide; arsenic compounds, except for those specified elsewhere in ANNEX VI CLP-ATP 18; wood powder; and soot) because CLP CoC was not available, because of the following: (i) Carcinogen data were lacking; (ii) There was no harmonized classification; (iii) Data are conclusive but not sufficient for classification.

Overall, for 23 chemicals out of 83, the converted CLP CoC resulted in a complete concordance with the original CoC (Table S5—Supplementary Material). The CoC of six EPA cases and three ACGIH cases were not available. For 12 chemicals, the CoC was referred to as a group of chemical compounds (and not a specific chemical). The comparison of the converted CLP CoC with the original CoC of the remaining sixty chemicals showed at least one discordant CoC in each of these chemicals (Table S6—Supplementary Material). A brief discussion on the results obtained from this last comparison have been reported hereafter; the chemicals for which similar reasons have been hypothesized at the base of the observed differences, in the CoC according to different systems, have been grouped into “clusters”. Before investigating these clusters, it is necessary to explain why clusters have been created.

3.2. Discrepancies in Classification of Carcinogenicity, Missing Data, and Unusual Results

A more detailed investigation (i.e., consulting official documents from the agencies) was necessary for some substances since these chemicals were not found in the consulted databases or were defined as non-carcinogen in one system, while for other systems the same were classified as 1A or 1B carcinogens. These chemicals were divided into four “clusters” as presented and briefly discussed in the following paragraphs.

3.2.1. Cluster 1—“Groups” of Chemicals

This cluster is made up of 29 chemicals (Table S7—Supplementary Material) and refers to chemicals which could not be identified using a specific CAS number when consulting databases of the considered carcinogen classification systems but could be identified using the CAS number of a group of compounds. Most of them are Arsenic, Chromium, and Nickel compounds, as well as Cool Tar and Cool Tar Pitches. As an example, it is interesting to focus on the cases of “cadmium (non-pyrophoric) and cadmium oxide (non-pyrophoric)” (CAS 7440-43-9 [1], 1306-19-0 [2]): these two were included in the original list of chemicals of interest but, as a result of a first search, they were not present in the NIOSH list. Consequently, both compounds were preliminarily classified as “non-carcinogen” in the database that was being created. Then, a second round of research was carried out which allowed us to establish that the “Cadmium fumes” (CAS 1306-19-0) entry of the NIOSH list also included cadmium oxide, thus defining “cadmium (non-pyrophoric) and cadmium oxide (non-pyrophoric)” as carcinogens according to the NIOSH list. These two examples can be understood as emblematic cases of the possible difficulty of correctly classifying mixtures, as well as of the different details of the lists of carcinogenic chemical agents considered.

3.2.2. Cluster 2—Mixture of Chemicals

This cluster consists of two mixtures: (i) Butane, containing $\geq 0.1\%$ butadiene; (ii) Isobutane, containing $\geq 0.1\%$ butadiene. These two mixtures are classified as 1A according to the reference CoC system (CLP Regulation) due to the presence of butadiene in concentrations above 1%, which represents the carcinogenic chemical in the mixture. Searching these two cases, using the CAS number, a non-carcinogenicity response was initially found for the IARC, NTP, and NIOSH CoCs while non-available data was found for the EPA and ACGIH CoCs. The differences between non-carcinogenicity results and non-available data in the CoCs are linked to the specific or unspecific consulted documents (non-carcinogenicity if the document is specific for carcinogens; non-available data if the documentation refers not

only to carcinogens). Moreover, for the CLP classification, a non-carcinogenicity response was found if we considered them as single chemicals (Table S8—Supplementary Materials).

3.2.3. Cluster 3—Chemicals Classified under Different CAS Numbers or with Different Names

This cluster consists of two chemicals: (i) Pitch, coal tar, high-temperature; (ii) Cadmium (pyrophoric). Both these chemicals have been listed in the consulted sources using a different CAS or using a different name with respect to those reported in the original list (Table S9—Supplementary Materials). The first case (“pitch, coal tar, high-temperature”) is not present in the consulted NTP RoC (Report of Carcinogens) with the CAS 65996-93-2 (as reported in the CLP list) but instead with the CAS 8007-45-2; the latter resulted to be associated with entries also in other CoCs. The second case “cadmium (pyrophoric)” (the name reported in the CLP list used as the original source) is not present in the NIOSH list with this name but instead with a different name (i.e., “cadmium dust”; this latter resulted to be associated with entries also in other CoCs).

3.2.4. Cluster 4—Discrepancies in Classification of Carcinogenicity

This cluster is made up of 16 chemicals (Table S10—Supplementary Materials) which resulted to be not listed in the NIOSH (14 cases) and NTP (2 cases) lists; moreover, further details were not found on these chemicals when searching for documentation in these two systems. Thus, these chemicals resulted in being listed as “non-carcinogens” in the database under construction for this study.

It should be noted that all the other considered CoCs have defined them as carcinogens.

4. Discussion

4.1. Overall Discussion

The results of the study confirmed that different classification systems for the carcinogenicity of chemicals can result in different classifications of the same chemicals, when considering diverse sources. Further, it is worth noting that often it is difficult to compare the CoCs proposed by different agencies. Overall, this may have implications for the hazard assessment process, which is the basis of risk assessment.

The first difficulty when dealing with the comparison of different CoCs has been found while accessing information on chemicals: some of the chemicals may be grouped using different criteria and, sometimes, the CoC of the specific chemical agent cannot be accessed. Further, all the consulted documentation has a different structure and sometimes it is not immediate to search for the substance of interest. An example could be the NIOSH occupational carcinogens list. It consists of specific documentation on carcinogens referring to occupational settings, but no further information is reported there (including the chemical’s CAS number).

In addition, for some chemicals, the NIOSH to CLP and NTP to CLP converted CoCs have been deepened, because a non-carcinogenicity classification has been found during the first research (matching chemicals based on their CAS numbers) and a discorded response when the other CoCs were defined. After the second search, in some cases, documentation related to the CoCs have been found, thus an alignment with other CoCs was possible. For other chemicals, only data related to animal experiments were found; therefore, no more information was collected.

Also, it is important to emphasize that in three cases the documentation was available but not a classification of a carcinogenicity.

These cases are PCB (PolyChlorinated Biphenyl), RCF (Refractory Ceramic Fibers), and erionite (Table S11—Supplementary Materials). To explain the issue on this topic, an emblematic case could be PCBs, for which a great diversity on the CoCs could be observed. First, the reference CLP CoC is not available; consulting the substance information on ECHA, the following statement is reported: “There is no harmonised classification and there are no notified hazards by manufacturers, importers or downstream users for this

substance". It should be noted that, despite the fact that PCBs could possibly be chemicals of concern in occupational settings, this class of chemicals does not fall into the CLP and REACH domain (i.e., PCBs are not substances produced to be placed on the market); therefore, it is possible that a harmonized classification for PCBs (and other chemicals attributable to this situation) is not available. Anyhow, IARC CoC defines PCBs as 1A carcinogens (and this could be considered as a primary source of information); at the same time, PCBs are not included in the NIOSH list of occupational carcinogens. It must be noted that the Current Intelligence Bulletin 45 (1986) [20] explains that a definite causal relationship between exposure and carcinogenic effects in humans remain unclear due to the inadequately defined populations studied and the influences of mixed exposures. However, since data from animal tests exist, NIOSH "recommends" that PCBs be considered as potential human carcinogens in the workplace. However, in 2019, the NIOSH Pocket Guide to chemical hazards [21] defines PolyChlorinated biphenyl [Chlorodiphenyl (42% chlorine)] and PolyChlorinated biphenyl [Chlorodiphenyl (54% chlorine)] as "potential occupational carcinogens".

Concerning the different classification systems, as reported in multiple studies [5,5–9], debates exist on both the crucial role of the classification systems and the importance of creating a new classification system which considers all the available scientific data.

Classification systems use different approaches to investigate carcinogenicity. Some of them are defined by some authors as "outmoded", who instead emphasize instead other systems as "more modern".

Table 2 reports some information about the criteria that agencies use in their consulted documentation [10,14,15,17,22,23].

It should also be specified that some differences that emerged in this study could be biased during the conversion and due to "practical" issues linked to the research of information and the available data of the consulted database or list of substances. In more detail, the observed difference might be related to the method of translation, rather than an actual difference in classification, as well as our decision to consider, for the indecision cases, the highest of the two categories of carcinogenicity as the righter.

A further example of a possible bias is "Cluster 1" chemicals, for which discordances could be caused by the decision to consider, where the specific substances have not been found (with the CAS number used by CLP CoC), a group of compounds within which that substance is represented. In this way, the CoC of the "generic" group of compounds also applies to a certain chemical. On the opposite, "Cluster 3" identifies substances that could have a different name but the same CAS number or practically the same chemicals listed under different CAS numbers. Further, consulting different sources for the purpose of this study, it emerges that some mixtures included in the original list are only included in the CLP database.

Different considerations could be made for "Cluster 4" chemicals of this study. This cluster groups substances where a severe discordance among NIOSH or NTP CoCs and other CoCs systems was observed, but for which other information has not been found or for which evaluations are not conclusive.

In this regard it is worth noting that NIOSH "Chemical Carcinogen Classification Policy" [24] assigns the definition of "occupational carcinogen" to a substance based on the NTP, EPA, and IARC CoCs. This policy evaluates the occupational relevance of these carcinogen designations to ensure that the appropriate hazards are accurately identified in occupational settings. In this way, NIOSH's efforts will be to evaluate worker's carcinogenic risk and to develop recommendations for risk management. If the scientific basis of the CoCs is occupationally relevant, NIOSH will list chemicals as an occupational carcinogen. If a chemical has not been evaluated by any of the three agencies, NIOSH considers nominating it to NTP for review or decides to develop its own carcinogen classification (using the criteria for carcinogenicity contained in the GHS).

Table 2. Aim(s), risk factor(s), and process of evaluation of the agencies' consulted documentations.

Source (Year of Publication)	Aim(s)	Risk Factor(s)	Process of Evaluation
IARC [22] (2019) Update every 5 years	To identify environmental factors that are carcinogenic hazards to humans	Environmental factors: chemicals, complex mixtures, occupational exposures, physical agents, biological agents, and lifestyle factors (1108 substances)	To review the published studies and assess the strength of the available evidence that an agent can cause cancer in humans
ECHA [10] (2023)	To prepare an Excel table containing all updates to the harmonized classification and labelling of hazardous substances, which are available in the CLP Regulation (Table S3 of Annex VI)	Hazardous substances (4372 substances)	To evaluate human epidemiological data, if available, and the results of long-term bioassays in laboratory rodents
US EPA [23] (2022)	To identify and characterize the health hazards of chemicals found in the environment	A chemical, a group of related chemicals, or a complex mixture (486 substances)	To analyze the mode of action *
ACGIH [15] (2023) Update every year	To published guidelines for use by industrial hygienists in making decisions regarding safe levels of exposure to various chemical and physical agents found in the workplace	Occupational chemical substances and physical agents (more than 700 chemical substances and physical agents)	To use sophisticated methods of bioassay and mathematical models to extrapolate the levels of risk among workers to interpret as to which chemicals or processes should be categorized as human carcinogens and what the maximum exposure levels should be
US NTP [14] (2021)	To prepare the Report on Carcinogens—a congressionally mandated report that NTP prepares for the U.S. Department of Health and Human Services Secretary	Chemical, physical, and biological agents; mixtures (256 substances)	To conduct a literature-based assessments using systematic review methods that integrate the relevant evidence across many different types of studies to reach conclusions about whether a substance is a cancer hazard
NIOSH [17] (Last Reviewed: May 2, 2012)	To define a list of substances considered to be potential occupational carcinogens	Chemicals (131 substances)	To use the following **: (1) Evaluation of chemical carcinogen hazard assessments developed by NTP, EPA IRIS, and/or IARC; (2) Nomination by NIOSH for classification by NTP; (3) Classification by NIOSH.

* The cancer guidelines emphasize the importance of weighing all the evidence in reaching conclusions about the human carcinogenic potential of agents. This is accomplished in a single integrative step after assessing all the individual lines of evidence, which contrasts with the stepwise approach in the 1986 cancer guidelines. ** When developing a new chemical carcinogen classification, NIOSH will use the criteria for carcinogenicity contained in the United Nations' Globally Harmonized System for Classification and Labelling of Chemicals (GHS), as included in the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard.

4.2. Strengths and Limitations of the Study

This study provides a conversion and translation database, built by consulting different public CoC systems (i.e., ECHA, IARC, EPA, ACGIH, NTP, and NIOSH). Filtering the database for a specific chemical using the name or CAS number allowed us to obtain

the result for all the consulted CoC systems, converted into the reference system for this study (CLP CoC) (or as published from the original sources, using the comparison table). The study is obviously characterized by some limitations: the very first is that the study only covered a relatively short list of chemicals. Thus, the database cannot be considered exhaustive of all carcinogenic chemical agents potentially present in working environments. Moreover, for this study, only European (i.e., CLP) and American (i.e., EPA, ACGIH, NTP, and NIOSH) CoC systems were considered, accompanied by an international system (i.e., IARC). Other agencies worldwide were not considered at this stage. It is worth noting that the database is intended to be a merely exploratory and consultative tool, only for research purposes, and that it is necessary to always refer to the legislation in force for the correct classification of the carcinogenicity of chemical agents of occupational interest. Classification data and conversions in the database are derived via the consultation of official public sources from the different agencies. Considerations performed in concordance and discordance with these are derived from the interpretation of authors.

4.3. Future Developments

A future development of this study could be the extension of the chemicals list and to extend the study to include other classification agencies, thereby enabling a more extensive comparison with the different classifications currently in force in the world; their assessment could be interesting and useful (speaking of the global market).

5. Conclusions

A freely available database and translation tool has been created. It reports a list of 83 chemicals of concern for occupational carcinogenic risk, classified as carcinogens or suspected to be carcinogens based on the CLP Regulation. For each of these chemicals, the classification of carcinogenicity proposed by European (CLP—considered as the reference system for this study), American (i.e., EPA, ACGIH, NTP, and NIOSH), and international (i.e., IARC) systems is reported, also “converted” into the CLP system. Discordances in the original CoCs of the considered chemical agents exist and critical issues have been defined. The proposed tool is expected to help risk assessors in the occupational field, if there is the need to have a comparison with different CoC systems.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/hygiene4010007/s1>. Table S1: Differences between the classification categories “NO” and “n.a.” for the classifications; Table S2: Columns information of the tool; Table S3: Original CLP, IARC, EPA, ACGIH, NTP, and NIOSH classification; Table S4: Conversion of IARC, EPA, ACGIH, NTP, and NIOSH classification in the reference CLP CoC; Table S5: A total of 23 cases classified with concordance in all the classifications. In red, cases where a specific CAS was not used, but the CAS referred to a group of compounds; Table S6: A total of sixty cases that have at least one discordant classification; Table S7: Case data for groups of compounds; Table S8: CLP COC and IARC, EPA, ACGIH, NTP, and NIOSH converted CoCs of Butane and Isobutane; Table S9: Case history of cluster 3; Table S10: Cluster 4 divisions; Table S11: CoCs—CLP converted from PCBs (PolyChlorinated Biphenyls), RCF (Refractory Ceramic Fibers), and erionite.

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Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists (United States)
CAS Number	Chemical Abstract Service Registry Number
CLP	Classification Labelling Packaging—European Regulation (CE) n. 1272/2008
CMRs	Carcinogen, mutagen, and reprotoxic agents
CoC	Classification of Carcinogenicity
ECHA	European Chemicals Agency
ECETOC	European Centre for Ecotoxicology and Toxicology of Chemicals
EPA or US EPA	Environmental Protection Agency (United States)
GHS	Globally Harmonised System
IARC	International Agency for Research on Cancer
NIOSH	National Institute for Occupational Safety and Health (United States)
NTP or US NTP	National Toxicology Program (United States)
NTP RoC	National Toxicology Program Report of Carcinogens
OHS	Occupational Safety and Health
WHO IPCS	World Health Organisation—International Programme on Chemical Safety

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