An approach to identify, prioritise and provide regulatory follow-up actions for new or emerging risks of chemicals for workers, consumers and the environment

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Abstract: This paper illustrates a comprehensive and systematic approach for the identification of new or emerging risks of chemicals (NERCs) for workers, consumers and the environment. The methodology illustrated here is composed of three steps: 1) signal identification; 2) signal evaluation and prioritisation and when necessary; 3) assessing follow-up actions for further risk management measures. During signal identification, new information with regard to adverse effects induced by the potential NERC is gathered using various information sources. Based on collected additional information, the causality between chemical exposure and the adverse effect is evaluated and prioritised. Finally, for those NERCs where there is sufficient proof of the causality with an adverse effect or the need for action, an analysis of possible appropriate regulatory risk management options is made. With this approach, NERCs can be efficiently identified with timely recommendations of follow-up steps, to reduce or eliminate the risk of the substance.

Keywords: exposure; prioritisation; evaluation; expert group; new or emerging risks of chemicals; NERCs; new risks; emerging risks; workers; consumers; environment; identification.

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Joost Bakker is an expert in environmental exposure assessment and emission estimation of industrial chemicals and biocides. He has worked in this field of expertise at RIVM since 2001. He has an MSc in Environmental Sciences and a BSc in Chemical Engineering. He has a special interest in industrial processes and the application of chemicals in products. His expertise was acquired through his involvement in the European chemicals risk assessment process, through guidance development, as well as contributing to several European Union risk assessment reports and the supply chain analyses for several types of chemical products. He is a member of the REACH Exposure Expert Group (REEG). Currently, he is involved in the early identification and prioritisation of emerging chemical risks for the environment.

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Theodoor Paul Traas is a Senior Expert in Ecological Risk Assessment and Regulatory Toxicology. He has a large experience in the development, testing and validation of risk assessment models and methods. He has co-edited a book on probabilistic risk assessment together with Dr. Glenn Suter (US-EPA) and Dr. Leo Posthuma (RIVM) and has been involved in international technical risk assessment for SETAC, OSPAR, and the Water Framework Directive. From 2005 to 2008, he represented RIVM in various international consortia for the development of REACH guidance. Once the REACH legislation was in force, he acted as Dutch co-member of the Member State Committee of the European Chemicals Agency in Helsinki. As of 2015, he is Head of the Department for Sustainability, Drinking Water and Soil at RIVM.

1 Introduction

The production and use of chemicals are important aspects of today's economy and modern life. People are exposed daily to hundreds of chemicals via the environment, food or consumer products such as clothing, cosmetics and electronics, pharmaceuticals and detergents. Workers may be exposed during the production, formulation and/or use of chemicals. Recent studies suggest that (low dose) exposure to (combinations of) chemicals may be associated with certain health problems (Goodson et al., 2015). The rise in human exposure to hazardous chemicals might be an important contributor to the observed international rise in the incidence of cancer, diabetes, neurological disorders and allergies [European Environment Agency (EEA), 2002, 2013; Prüss-Ustün et al., 2011; Trasande et al., 2015]. Of particular concern are sensitive or vulnerable groups such as the unborn child, young children, women in the fertile age and the elderly.

Unidentified risks of chemicals are a growing concern because of the current speed at which novel chemicals and products are placed on the market. The timely identification of potential new or emerging risks of chemicals (NERCs) is crucial to safeguard workers, consumers and the environment. The fact that chemicals can have unexpected negative impact on human or environmental health after market introduction is not new (EEA 2002, 2013). Clear examples on how such threats were regulated include organochlorine pesticides in the '50-'60s and more recently perfluoroctane sulphonate (PFOS) and perfluoroctanoic acid (PFOA), resulting in restricted or banned use by international regulations (EU-POP regulation 2004; OSPAR 2012). These threats may not be completely controlled or known prior to their introduction into the market. Experience shows that it often takes a long time before signals are picked up by societal institutions and even longer for these to react (EEA, 2013). Therefore, the establishment of a pro-active system for the identification of NERCs is essential for timely implementation of risk reduction measures for the protection of human health and the environment. To the best of our knowledge, a systematic approach does not yet exist and an integral assessment of information or strategies on follow-up actions after the identification of new or emerging hazardous substances are still lacking. The aim of this paper is to illustrate a comprehensive and systematic approach towards an early warning system for identifying NERCs for workers, consumers and the environment.

2 Methodology

2.1 Defining NERCs

There are a variety of terms and definitions for new or emerging risks, such as new risk, emerging risk, emerging issue, emerging pollutant, emerging substance or contaminant of emerging concern. These can be grouped into three main categories: newly created risk, newly identified risk or increasing risk. An overview of typologies of NERCs adapted from the European Agency for Safety and Health at Work (EU-OSHA, 2009) is provided in Table 1. There is no single accepted definition for emerging risks, but they are generally characterised by uncertainty regarding their potential consequence or probability of occurrence. According to the International Risk Governance Council (IRGC, 2015) a NERC is defined as: "a new risk or a familiar risk that becomes apparent in new or unfamiliar conditions." Following the definition provided by Locklear (2011), a NERC is defined as "a new manifestation of risk, of a type which has never before been experienced."

Table 1 Typologies of NERCs used in this study

New risks	*Emerging risks*
• Causality between exposure and detrimental effect and • Risk caused by new types of substances on the market, new processes, new technologies, new types of workplaces, new types of exposure routing; or social or organisational change or environmental changes or • New scientific knowledge allows a longstanding issue to be identified as a risk or • Chemicals that have potential PBT (persistent, bioaccumulative and toxic), vPvB (very persistent and very bioaccumulative) or ED (endocrine disruption) properties	• Causality between exposure and detrimental effect and • Number of hazards leading to the risk is growing or • Likelihood of exposure to the hazard leading to the risk is increasing, (exposure degree and/or the number of people exposed) or • Effect of the hazard on the environment or the health of workers or consumers is getting worse or • More or new information becomes available or • Substance detected in the environment to a level that might indicate effects

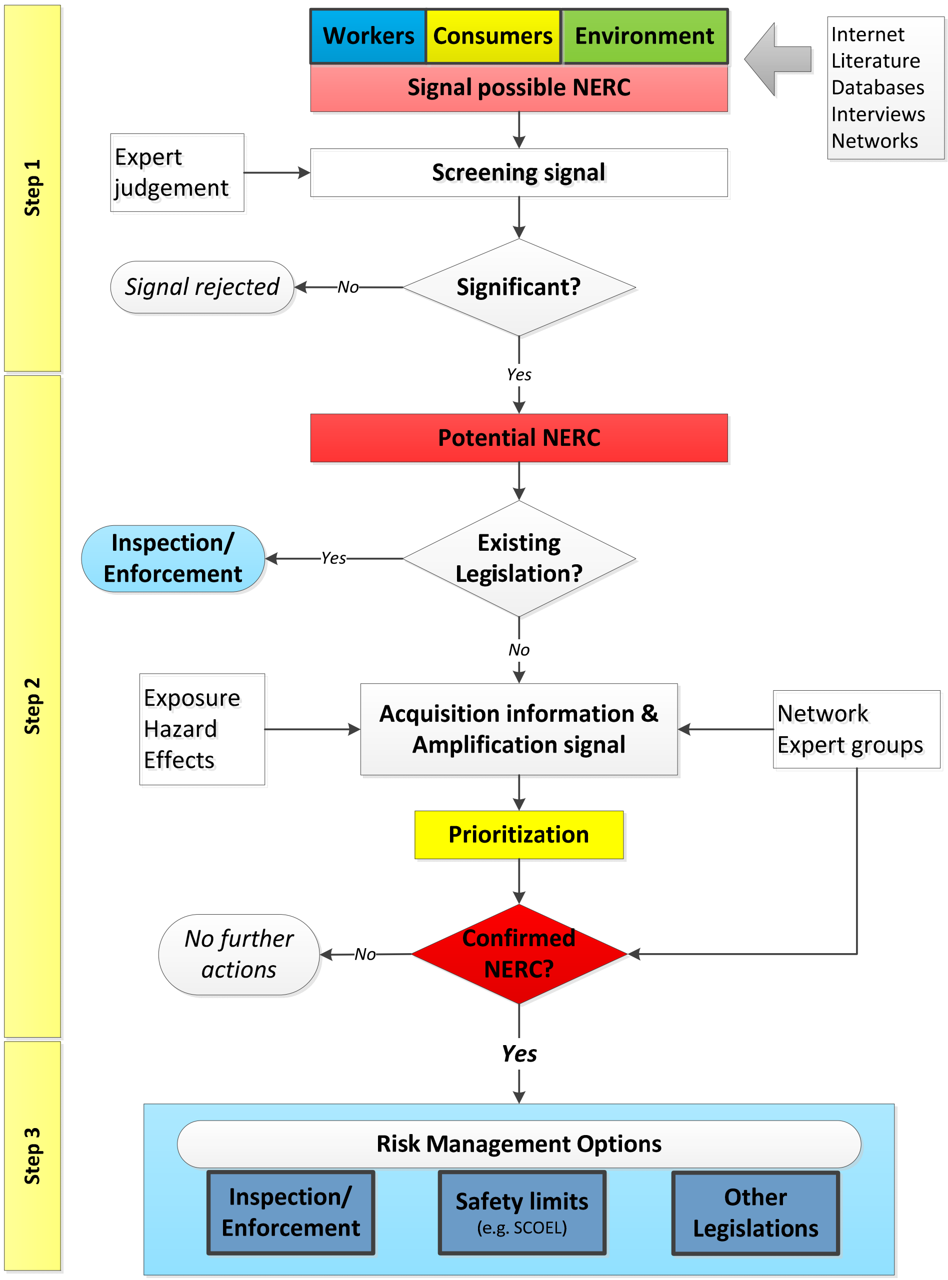
We consider a new or emerging risk as a risk caused by new types of substances being introduced on the market, newly identified exposure routes resulting from new technologies, uses or industrial processes and new scientific knowledge (newly identified hazards). Furthermore, risk might become apparent because of increasing levels and scale of exposure.

This method focuses on establishing a pro-active surveillance system for risks to human health and the environment caused by chemicals. Chemicals in scope include, e.g., industrial chemicals, biocides, pesticides, food and feed additives, food packaging chemicals, cosmetics, medicines and metabolites and by-products (for instance from fuel combustion). With regard to the environment, focus is on the air, water and soil compartments. For human health, focus is on consumers and workers with special attention for exposure occurring directly via consumer products, consumption of food and exposure to chemicals at the workplace or indirectly via the environment (air, drinking water or food).

2.2 General approach

The general approach for the pro-active identification of NERCs for workers, consumers and the environment consists of three steps (see Figure 1).

Figure 1 Scheme of general approach for the identification of NERCs consisting of Step 1: signal identification, Step 2: signal evaluation and prioritisation and Step 3: follow-up actions (see online version for colours)



Step 1 *Signal identification* of potential NERCs using various information sources (e.g., scientific literature, news sites, websites, electronic databases and stakeholder networks). In case of potential risks for humans (workers or consumers), epidemiological research and case reports are considered valuable sources. Each signal is screened by expert judgement following the typologies of NERCs provided in Table 1. This screening step is essential for rejecting or assigning the signal as a potential NERC

Step 2 *Signal evaluation and prioritisation*. If the substance has already been identified as being of concern before and regulatory measures have already been implemented, the identified signal can be forwarded to enforcement or inspection authorities. Further evaluation is pursued on those signals that have not been forwarded. For these, additional information is collected on exposure and hazard effects. Evaluation of this additional information includes the involvement of specific expert groups with the aim to amplify the signal through combining the various information sources and to assess the possible chemical stressors that could be responsible for the signal. This process of expert evaluation also includes the results from the quantitative *prioritisation* of all the information on the signals received to come to a priority list of potential NERCs.

Step 3 *Follow-up by risk management measures*. High priority potential NERCs will be further assessed to analyse the possible need and options for risk management measures to reduce or eliminate the risk. Such measures may include, e.g., the derivation of environmental quality standard, occupational safety limit, restricting its use or proposing harmonised classification and labelling.

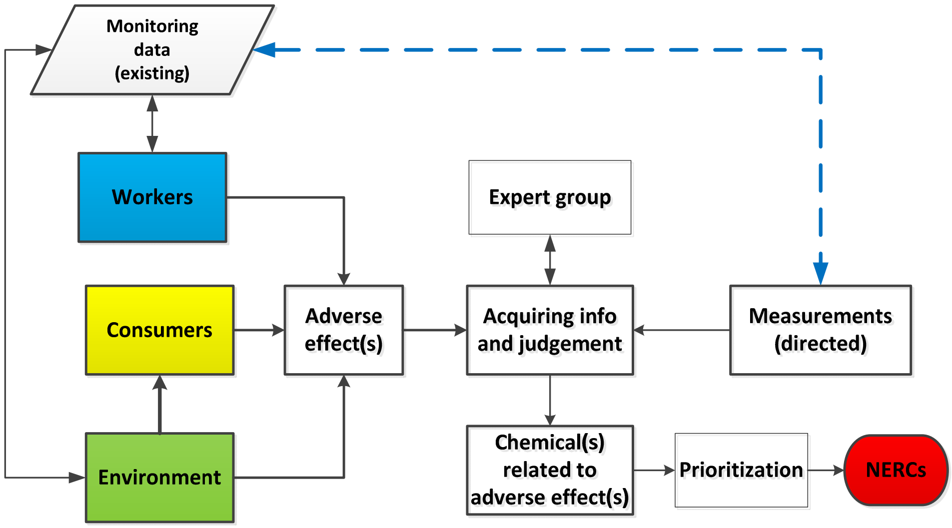
The identification of possible NERCs is performed for workers, consumers and the environment in parallel. Experiences and methodologies are shared allowing the possibility to exchange information on NERCs (Figure 1).

3 Results: pro-active identification of NERCs

3.1 Signal identification

For each protection target, the first crucial step is signal identification followed by collecting relevant information on the potential NERC signal. The general scheme for the identification and evaluation of signals of possible NERCs for the three protection targets (workers, consumers and the environment) is illustrated in Figure 2. The process of identifying NERCs varies slightly for each protection target. In case of *workers*, the identification process is usually triggered by an observed adverse health effect in workers and the likelihood of a causal relationship with exposure to chemicals at the work place. In the case of *consumers*, the identification of a NERC is based on the collection of information on an adverse human health effect caused by exposure to consumer products which might eventually lead to the identification of the chemical(s) causing the adverse effect. For the *environment*, (bio)monitoring data for the environment provide evidence for establishing NERCs. Here, more than for consumers and workers, the identification of a NERC is found to be severely hampered by the presence of numerous other compounds in the environment and their highly fluctuating concentrations. The resulting combined toxicity makes it very difficult to determine causality between an adverse effect and a single chemical stressor (NERC).

Figure 2 General scheme for the identification and evaluation of NERCs (see online version for colours)



Note: Scheme of Step 2 in Figure 1; blue broken line represents exchange of information between measurements (directed and existing monitoring data while double arrows represent exchange of information).

The development of the methodologies for the identification of NERCs for each protection target is described separately in the paragraphs below following the principles of Figure 2.

3.1.1 Workers

The identification process of a potential NERC for workers requires several complementary methods. The proper method depends on the characteristics of the health problems to be investigated, such as its nature and seriousness and the strength of the causal link with the exposure. In case of a rare disease with a strong etiological relationship between job description and the health complaints, collection of case reports using a clinical watch system is more suitable than epidemiological research such as case control or prospective or retrospective cohort studies. In a clinical watch system, cases of health impairment are reported and disseminated among professionals with the intention to investigate a possible causal relationship between the exposure and the reported health effects. The Netherlands Centre for Occupational Disease together with the Belgian Catholic University Leuven launched the online service SIGNAAL (2017) where suspicions about new relations between health and work can be reported and reviewed by a panel of occupational specialists. In case of frequently-occurring health effects with a weak cause-effect relationship, epidemiological research among large groups of employees is a more appropriate method. Data mining in databases of case report notification registries is a valuable tool for epidemiological research, especially when information on exposure is incorporated in the database. A different kind of research is cluster analysis which investigates a series of coincident cases (time and place coincidence). Another method to investigate NERCs is to perform health surveillance among exposed workers. This prospective method is useful since a causal relationship between the level of exposure and possible health effects is easier to prove.

Systematic literature searches, both in scientific literature databases and on important websites of organisations engaged in the identification of new or emerging risks is an important method to track potential NERCs as soon as possible.

3.1.2 Consumers

The methodology for identifying NERCs for consumers consists of a systematic data collection system into a *database*. Potential cases retrieved by screening various information sources (i.e., literature search, network and consumer complaints) are gathered in a *database* (Bakker et al., 2014). Beginning with signal collection, the following information sources are systematically screened to obtain information on the possible link between chemicals in consumer products and health effects:

1 *Literature search. Post-marketing surveillance literature search* including international government reports (Danish Environmental Protection Agency[1], the German BfR[2], Health Canada), *internet searches* including Dutch and international media reports and *database searches* including ChemicalWatch[3], RAPEX[4] weekly report listings (EC RAPEX, rapid alert system for dangerous non-food products) and reports from the National Poison Centre (NVIC).[5] For *pre-marketing surveillance* literature search, sources such as Cosmetics Design Europe[6] and consumer product trends were used.

2 *Network* of experts which share signals.

3 *Consumer complaints* through the Consumer Exposure, Skin Effects and Surveillance (CESES) Program[7] which was initiated at the request of the Netherlands Food and Consumer Product Safety Authority (NVWA) and the Ministry of Health, Welfare and Sport (VWS). In CESES, the reported consumer complaints from cosmetics use are assessed by dermatologists as part of a post-marketing surveillance system.

The identification of NERCs for consumers consists of also collecting hazard, potency and exposure information of chemicals in consumer products with reported adverse effects. This information is gathered in a *database* consisting of chemicals in consumer products with reported adverse effects and it is housed in The National Institute for Public Health and the Environment (RIVM, The Netherlands). All information relevant for the identification of consumer risks and additional data on type of exposure and consumer product details is collected in this *database*. Information collected includes the severity of the effect as a result of product exposure, effects observed in a sensitive group (e.g., infants, children, elderly) and the probability of exposure. Product categories were assigned to discriminate between the different types of products and to better define various types of exposures. Important categories are ‘cosmetics’ (used on a daily basis), ‘household products (used on a weekly or monthly basis) and ‘toys’ (used by sensitive groups). In addition, chemical categories were added to allow identification of important groups of chemicals [e.g., phthalates, flame retardants or parabens, carcinogenicity, mutagenicity, reproductive toxicity or respiratory sensitisation (CMRS)]. Chemical categorisation is useful to filter groups of chemicals for which regulatory measures have already been implemented and allows for the identification of products with the potential for high consumer exposure or high hazard potential.

In addition, an assessment is made as to whether the signal has previously been identified and actions or regulatory measures have already been implemented. A *recurring signal* is therefore defined as a known historical risk due to the presence of a substance in a consumer product. Here, the identified signal is forwarded to enforcement or inspection authorities. If a potential NERC is identified, additional information is gathered where possible on the identity of the substance, its classification (self-classification by the notifiers and/or harmonised classification), the use of the substance, the seriousness of the health effect and the amount of the exposure to the substance in relation to the health effect reported.

3.1.3 Environment

For the identification of environmentally relevant NERCs internet search systems, scientific literature searches, studies using environmental monitoring data and expert consultation are employed.

Digital media are monitored by creating lists of various categories of key words such as hazardous effects and properties, environmental compartments and exposure routes, chemical analytical information and methods. Automated searches are created by applying and combining these lists to a media monitoring tool (HowardsHome[8]) that searches selected news sites and social media. Results are collected on a weekly basis. Another internet screening is performed with the European Media Monitor (EEM) developed by the European Commission's science and knowledge service, the Joint Research Centre (EC-JRC-EEM, 2015) with a set of hazardous compounds, categories of compounds and environmental effects focusing on endocrine disrupting effects. This internet screening takes place every ten minutes and hits can be seen immediately. The list of key words has been developed in close collaboration with an experienced scientific news reporter/journalist.

An additional source of information is environmental monitoring data. Studies were carried out by Water Cycle Research (KWR) institute and RIVM for matching regulatory (REACH) and monitoring data (Kolkman and ter Laak, 2012; ter Laak et al., 2015). These studies aimed to explore whether (in situ) environmental monitoring data can be used to support regulatory activities within REACH. For this purpose, GC/MS and LC/MS databases of monitoring data of organic chemicals in Dutch surface waters and ground water were searched for chemicals listed by REACH and other priority lists. Simultaneously, in both studies a much wider screening was done on all registered high production volume chemicals for which single chemical structures are available. These non-targeted screening data obtained with liquid chromatography coupled to high-resolution mass spectrometry (LC-HRMS) were matched with listed REACH and other priority chemicals. Another study involved a desktop study commissioned by the RIVM and carried out by The Institute of Environmental Studies (IVM) (Lamoree, 2014). This study was carried out in order to obtain current information about the occurrence of endocrine disruptors and observed ecological effects in large Dutch surface waters.

Results from both methods are gathered and the relevance of the identified signals is discussed in an expert panel. The informal expert panel consists of a small discussion group of experts covering a large scope of relevant disciplines. The aim of this group is to link information on observed and reported effects to the exposure information such as monitoring data, the use of (new) chemicals, new applications, technological and social developments and process innovations.

3.2 Signal evaluation and prioritisation

3.2.1 Workers

Signals of potential NERCs obtained in the identification phase are discussed in a "Dutch expert group of new or emerging risks of substances", established in 2014 and consisting of (occupational) physicians, toxicologists, industrial hygienists and epidemiologists. The evaluations within the Dutch expert group are discussed within the network on 'Monitoring trends in Occupational Diseases and tracing new or Emerging Risks in a NETwork' (MODERNET). MODERNET is an international network of professionals that study potential NERCs and share knowledge with each other with the intention to stimulate taking measures to reduce the risk. A prioritisation system was developed to concentrate on those potential NERCs with the highest impact on health (Palmen and Verbist, 2015). In this system, for every individual potential NERC, additional information is gathered on the identity of the substance, its classification (self-classification by the notifiers and/or harmonised classification, if available), the use of the substance (which branch or process), the seriousness of the health effect, the amount of the exposure to the substance in relation to the health effect reported (if available) and a qualitative calculation of the risk. Once prioritised, signals on potential NERCs may be amplified by initiating additional research and/or finding additional cases by looking into databases with information on health effects, job description and exposure. This is a very important step that may result in confirmation of a potential NERC into a NERC for with options for risk management measures will be considered.

3.2.2 Consumers

The potential NERCs for consumers are evaluated, amplified, prioritised and confirmed by an *expert group*. Current work is invested in the establishment of a national and international *expert group* (international network on new or emerging risks of chemicals, INNERC) to help in the identification of NERCs in consumer products. In similarity to the methodology set up for workers, all the data is reviewed and assessed by INNERC in a qualitative risk assessment. Several approaches have been proposed for the evaluation and prioritisation of chemicals in consumer products (Schuur and Traas, 2011; Nijkamp et al., 2014; Woutersen et al., 2015).

In the proposed methodology, signal evaluation is composed of gathering information on toxicity, potency and exposure of a chemical in a consumer product. Toxicity information is obtained from various sources including the REACH registration dossier of the substance, whether the substance has a harmonised classification (CLP) and publications in PubMed and governmental reports. A category score is derived by giving higher priority to carcinogenicity and mutagenicity, followed by reproductive toxicity, respiratory sensitisation and acute toxicity. Potency information is derived from the

ECHA dissemination database either through the published the selection of the lowest derived-no-effect-level (DNEL) or derived-minimal-effect levels (DMELs) for the general population. A potency score is derived as proposed by Woutersen et al. (2015). In terms of exposure, an exposure expert score is derived as proposed by Woutersen et al. (2015) where the ECETOC targeted risk assessment (TRA) tool for consumer exposure was used to derive expert exposure scores for various product and article categories in the ECHA database. The scores of three components, exposure estimation, exposure frequency and the distinction between usage and consumption are multiplied to obtain an exposure score.

For prioritisation, the *hazard score* is obtained by adding the classification score with the potency score and the *risk score* is derived by adding the hazard score to the exposure score. Additional factors taken into account in the prioritisation are the occurrence and exposure of susceptible populations such as the unborn child, young children, women in the fertile age and the elderly.

For signal strengthening, the INNERC *expert group* assesses additional exposure and toxicity information via reports from The Scientific Committee on Consumer Safety (SCCS), the Consumer Product Safety Commission (CPSC), Health Canada and/or important hazard, exposure and toxicity information in the literature (PubMed). Expert judgement within the group might be implemented in instances where the CMRS properties of a substance are not known or confirmed. This is a very important step that may result in confirmation of a potential NERC into a confirmed NERC (Figure 1), which may lead to measures to control the risk.

3.2.3 Environment

If a potential NERC is identified for the environment, further information is searched on hazardous properties and the exposure potential. A confirmatory check on existing legislation and measures is performed before further data generation. If the specific concern related to a substance has already been identified before and actions or regulatory measures have already been implemented, the identified signal can be forwarded to enforcement or inspection authorities if needed. After this check, a search for additional information on exposure, hazardous properties and toxic effects is carried out. The basis for the prioritisation is the calculation of risk scores from this information, resulting in a priority list. The amplifying process includes the participation of expert group identifying further data needs and confirmation of a potential NERC.

The scoring is based on a hazard score and an exposure score. Different hazard and exposure categories are defined. Within each category, scoring is done by assigning higher priority to more severe toxicological end-points or a higher the degree of toxicity. Properties taken into consideration include endocrine disruption, persistency, bioaccumulation, ecotoxicity and CMR properties. For exposure scoring, exposure categories are defined-based measured environmental concentration or on the combination of the main type of use of a chemical and the market volume. Types of use that imply high releases are given higher priority, the same for the market volume. Combining the release score and market volume, results in an exposure score. A risk score can also calculated by comparing monitoring data to available environmental quality standards or known no-observed effect levels.

3.3 Follow-up actions

3.3.1 Workers

Several actions are possible if a potential NERC becomes a confirmed NERC. If a substance is already regulated, the new risk will be reported to the relevant inspection department(s) so that measures can be taken. Communication of a NERC via an alert to professional societies focused on occupational health and safety is very important. Professionals such as industrial hygienists, safety engineers, occupational physicians, etc. should be informed as soon as possible about a NERC in order to check whether the NERC is used in the companies they advise. If a NERC is already on any of ECHA's lists of substances and is being investigated by ECHA or one of the member states in one of the REACH processes, they will be informed on the confirmed NERC. If a substance is not on any of ECHA's lists, a risk management options analysis (RMOA) may be performed. A RMOA is a case-by-case analysis, conducted by the authorities, to conclude if a substance should be identified as a concern; and if additional regulatory instrument(s) should be proposed to manage the risks from its use to human health or the environment. For workers, a comprehensive overview of possible follow-up actions for (potential) NERCs has been reported (Palmen and Verbist, 2015; Palmen et al., 2013).

Table 2 lists an example for workers. Diacetyl is a food flavouring substance which may cause severe lung disease after inhalation exposure by workers. Signalling this concern led SCOEL to advise the reduction of the indicative occupational exposure limit (I-OEL) by a factor of five and NIOSH to develop guidance in a variety of areas to reduce workers' exposures to diacetyl through engineering controls, best work practices and techniques for monitoring airborne exposure (EC 2014; Dunn et al., 2015).

3.3.2 Consumers

The possible *follow-up* measures depend on the risk management options within the relevant (regulatory) frameworks of the identified NERC. Within Europe some follow-up actions under REACH include a RMOA, the proposal for harmonised classification or the proposal for a restriction of a substance in consumer products. If the substance is in a cosmetic product, actions under the cosmetics regulation can also be taken.

Table 2 lists an example for consumers. P-phenylenediamine (PPD), for instance was identified as a potential NERC in 2015 and after extensive information gathering, a RMOA was performed by The Netherlands. PPD is primarily used in cosmetics (i.e., hair dyes, henna tattoos) and is already heavily regulated, however, worker and consumer exposure were identified to still be problematic. In the RMOA, several options were suggested including:

1 the harmonised classification for skin sensitisation and acute toxicity

2 the advice to the SCCS to re-evaluate cosmetic products containing PPD for workers and consumers and to consider a substance evaluation as a follow-up action and

3 the restriction (lowering concentration or ban) of PPD in textiles, tattoos and permanent make-up.

This is a good example where follow-up actions are directed towards the protection of both workers and consumers.

Table 2 Examples of indicated NERCs with proposed methodology for consumers (C1), workers (W1) and the environment (E1)

No.	*Substance*	*Product description*	*Issue or reason for concern*	*Status risk*	*Proposed action*	*Executive state/body*	*Source*
W1	2,3 butanedion (diacetyl)	Food flavouring	Inhalation exposure may cause severe lung disease bronchiolitis obliterans	NERC	I-OEL down to 0.02 ppm (SCOEL); new guidance to reduce workers' exposures (NIOSH)	SCOEL (EU) and NIOSH (USA)	Dunn et al., (2015), EC (2014)
C1	p-phenylene-diamine	Used in cosmetics (i.e., hair dyes, henna tattoos)	Potent skin sensitiser	NERC	RMOA submitted to ECHA	NL, ECHA	Jacob and Goldenberg (2014)
E1	Triclocarban	Substance is used as a preservative (biocide) in paints, inks, fillers and cleaning products	The substance is comparable to triclosan with respect to function and use. Measured concentrations in USA indicate a concern	NERC	Substance is registered under REACH but not as a biocide according to the biocidal products regulation. No or very limited monitoring data available for EU	NL, ECHA, Ctgb*	Chalew and Halden (2009)

Note: *Dutch Board for the Authorisation of Plant Protection Products and Biocides.

3.3.3 Environment

If the NERC is confirmed, *follow-up* measures might include a detailed assessment in order to determine the best way to address the risk. Similarly to consumers, for substances which cause a risk when used within a specific domain with specific regulations like cosmetics, plant protection products or biocides, this risk is most likely best addressed within these regulations but the identified risk may also be linked to issues not covered in the specific regulations such as the aggregated exposure from all the different uses in the case of biocides. When a substance that is used outside the scope of a specific regulation causes a risk, more overarching legislation such as the REACH needs to be considered.

When substances that are strictly regulated due to their properties such as CMRs, persistent, bioaccumulative and toxic (PBTs) and/or are very persistent and very bioaccumulative (vPvB's) are found to be present in the environment, a reconsideration of the risk reduction measurement plans that are in place may be triggered. Furthermore, as these groups of chemicals are regulated based on intrinsic hazard properties and not primarily on exposure or risk considerations, the presence and frequency of occurrence at various sites (both in place and time) would initially be more informative of the risks than proving the risk for adverse effects at these concentrations.

Table 2 lists an example for the environment. Triclocarban (E1) is a potential alternative for the extensive use of triclosan with known adverse effects, the compound occurred in USA surface water at levels of potential environmental concern. Triclocarban is an antibacterial agent and an alternative for triclosan. As an active ingredient in biocidal products, the substance falls under the Biocides Regulation in Europe. Triclocarban is not on the list of approved active substances of the biocides regulation in the EU though. Instead, the substance is registered under the REACH regulation for application in consumer products such as amongst others in personal care products, paints, air fresheners, and cleaning agents. It is technical function in the registered products is not disclosed in the publicly available information. Comparable to triclosan, a large proportion of triclocarban is used in products that are considered biocides or not depending on the claim made on the function of the product. In these cases, the substance could probably be used as a preservative or disinfecting agent that are in fact biocidal applications but will not be authorised in accordance with the Biocides regulation. The case is under investigation by the Dutch authorities. Further investigation on triclocarban did not lead directly to an environmental concern but as a potential replacement of triclosan (a PBT substance) and the intention to use triclocarban (not a PBT substance) for wide dispersive uses personal care products and cleaning agents it has the potential to become environmentally relevant.

4 Discussions

Here, we present a pragmatic methodology for the pro-active identification and confirmation of NERCs for workers, consumers and the environment. The methodology presented here is to the best of our knowledge, the first with the ambition to aggregate signals of potential NERCs for workers, consumers and the environment. This is based on the premise that possible concerns for consumers may sometimes be more readily observed or identified in the worker population and that substances identified in increasing concentrations in the environment may point at increase use or new sources that may lead to possible significant exposure of both workers and consumers. PPD is an example of such a case where follow-up actions were for both consumer and worker protection. Furthermore, substances of environmental concern may be signalled in consumer products before these are encountered in significant concentrations in the environment. This is especially relevant for down the drain consumer product such as washing and cleaning agent and cosmetics. Examples of these are substances with persistent properties such as octamethylcyclotetrasiloxane (D4) and decamethylcyclopentasiloxane (D5) that are widely applied in cosmetics and are now subject to restrictions under the REACH regulation. Substances with endocrine modifying properties in consumer products, for instance in certain UV-filters in cosmetics, although in these cases mainly classified as human endocrine disruptive, may be regulated before clear environmental effects are demonstrated.

4.1 Challenges with signal identification

It is very challenging to establish and maintain a comprehensive and systematic approach for identifying NERCs for workers, consumers and the environment. The active and periodic screening of multiple sources of information such as scientific literature, news sites, websites and electronic databases is crucial but labour-intensive. In addition, having a broad national and international network is key for signal identification. For workers and the environment, networks such as MODERNET and NORMAN are essential for knowledge sharing of potential NERCs. For consumers, the INNERC network is currently being assembled.

Because the health and environmental effects are often delayed, it is challenging to find a way to deal with lag time between exposure and measurable effects. Systems like the one presented here can play a significant role for the timely identification of NERCs and prevent possible harmful effects of chemicals for man and the environment. The challenge is to identify chemicals of concern that we are not yet aware of and that might become a potential risk and act upon appropriately. Signal identification is therefore essential and different ways should be explored. In addition to digital media monitoring and chemical analytical methods as non-target screening, foresight approaches could also be used. 'Chemical trend watching' and tracking recent technological developments need to be explored. The focus should be on what kind of chemicals will be developed in the near future considering recent developments in the area of for instance bio-based economy, circular economy, sustainable energy production and demographic developments.

4.2 Challenges with signal evaluation and amplification

The major challenge for the signal evaluation and amplification is dealing with lack of data to sufficiently establish a causal relationship between an adverse effect and the chemical exposure. Multidisciplinary expert groups with knowledge on both exposure and effect are fundamental in the evaluation and amplification process.

For workers, information on exposure is often lacking. For this reason, prioritisation of signals is based on an impact analysis which is the product of the severity of the effect on health (impact), the evidence of occurrence (likelihood) and the actual manufacture and/or use of the potential NERC in companies. A major challenge is to obtain consensus among scientists/experts on the causal relationship between the exposure and the health effect, since there are no ready to use algorithms for judgement of evidence of causality (Verbeek, 2012). These discussions take place in national and international expert groups.

For consumers, a more pragmatic approach is used where additional exposure/hazard/effect information is gathered. Here, a hazard/potency and exposure score is calculated for each potential NERC. Prioritisation of the signals is based on the product score and whether the consumer is part of a sensitive or vulnerable group such as the unborn child, young children, women in the fertile age and the elderly. A major challenge here is to obtain enough information to perform the evaluation and prioritisation. In many instances, only acute information and local skin effects are detected and CMR effects induced by chemicals in consumer products are more challenging to detect.

For the environment, data collection is a key point and should be done as efficiently as possible. Ideally, the data needs should be collected and easily available and retrievable at a central point. Platforms such as IPCHEM portal (EC, 2017) and eChemPortal [OECD, 2017] can fulfil this task to make a large number of data sources available at a centralised point. In addition to data collection, expert consultation is needed in order to get better insights in the causal relationship between the occurrence and possible effects as well as for providing additional information from scientific research at an early stage.

The involvement of specific expert groups at this stage of evaluation and prioritisation is important to amplify the received signal. An occurring major challenge for the scientific community and experts is to reach consensus with regard to the link between the adverse effect and the chemical exposure. It is important to note that generally this assessment is performed on a case-by-case basis. The national and international networks of experts which are involved in assessing the causality between chemical exposure and the health effect play a vital role in deciding whether a potential NERC will be confirmed as a NERC for which the assessment of follow-up risk management measures should be initiated. The system presented is unique in that there is close contact and collaboration with regulatory agencies and monitoring organisations to facilitate timely follow-actions; an imperative component for an efficient signalling methodology.

4.3 Challenges with follow-up actions

Once a signal is confirmed as a NERC, a major challenge is to assess and motivate most appropriate risk management measures. In order to identify a need to follow-up on a signal it is often required to specify the health or environmental concern (hazard) and the area to which the concern applies (workers, consumers, environment, specific products or specific practices), i.e., to map hazard, use and exposure information and regulatory measures already in place. Many regulatory actions require substantiation of the concern. If the first follow-up action is for instance to request further information from industry, one has to motivate how this information request is expected to impact possible risk management measures. Especially in the case of early identification of NERCs, this information may simply not be there (yet) and the signal, though identified as NERC, is still likely to be too premature to follow-up within established regulatory frameworks (as these are not developed with a focus to deal with new or emerging risks). In these cases, targeted monitoring of the NERCs by national or international (research) initiatives may be needed to further amplify the signal. Links to other initiatives such as the prioritisation framework for identifying emerging substances in environmental samples developed by the working group on prioritisation of emerging substances of the NORMAN Association (Dulio and von der Ohe, 2013), the position statement on emerging and newly identified health risks (SCENIHR, 2013) and the five-yearly aggregated review on environmental risks of chemicals by the EEA (2002, 2013) are also important for timely follow-up actions.

4.4 Policy and regulatory challenges

There is a clear wish from regulators to react proactively on risks of chemicals, for example as part of following a precautionary approach. In practice though, this wish involves high regulatory challenges in terms of taking regulatory action in the face of uncertainty. Current assessment strategies require information suggesting the need to take further measures. This often implies evidence for a strong indication of a severe effect or data identifying an actual risk for society. Proactive action on the other hand suggests action before such evidence for severe effects or risks for society arise. As a consequence, a challenge for policy makers is to reach further consensus with limited signal information and taking into account possible (socio)economic consequences of such a measure. At present, this is a highly debated topic.

4.5 Industry challenges

For industry, there are huge costs associated with not knowing the risks of chemicals in products and supply chains. The hidden liabilities of not knowing the risks chemicals in products include fines due to non-compliance, product recalls, loss of sales, market shares and valuation, high costs for product reformulation, supply chain disruption and tarnished brand reputation (Rossi, 2014). Industry needs to move towards a proactive business model where there is an investment in knowing the risks of chemicals in products and production chain, training suppliers and testing products. Strategic options for managing the risks of chemicals in product and supply chain and creating long-term value by implementing systems to know the risks chemicals in products and supply chains are needed to reduce the emergence of NERCs (Rossi, 2014).

5 Conclusions

This paper illustrates a comprehensive and systematic approach for identifying NERCs for workers, consumers and the environment. This pro-active and pragmatic methodology consists of potential NERC identification, prioritisation, evaluation and the implementation of follow-up actions to reduce or eliminate the risk of confirmed NERCs. With this approach, NERCs can be efficiently identified with timely recommendations of follow-up steps, to reduce or eliminate the risk of the substance. Further improvement of the methodology is ongoing by enhancing the interaction between signals from risks from workers, consumers and the environment as well as involving other actors like NGOs and Trade Unions and further application of the search engine to data mine information on substances.

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Notes

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