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Review

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Review

Mapping commercial practices of the pesticide industry to shape science and policymaking: a scoping review

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Abstract

There is a growing body of evidence for how health harming industries (HHIs) engage in similar practices to influence science and policymaking. However, limited attention has been paid to the pesticide industry within the commercial determinants of health (CDOH) field. We conducted a scoping review to map practices adopted by the pesticide industry to influence science and policymaking and to assess the breadth and focus of the associated literature. We included 31 documents and categorized the extracted data using a typology of commercial practices. The documents described how major pesticide companies, and their trade bodies, have acted to influence science and maintain favourable regulatory environments while undermining the credibility of researchers and agencies that publish findings threatening to their commercial interests. A large proportion of the literature consists of historical analyses, narrative reviews, commentaries/perspective pieces, and investigative reports published in the grey literature, predominantly informed by analysis of internal industry documents and freedom of information requests. Most studies focus on high-income settings. There were a limited number of primary peer-reviewed empirical studies that explicitly aimed to study the practices of the pesticide industry from a CDOH perspective. However, our findings show that major pesticide companies adopt political and scientific practices highly similar to other HHIs. The review shows a critical need for research on the pesticide industry's current practices in low- and middle-income countries where the negative impacts of its activities on health and the environment are likely to be more marked.

Keywords: pesticide industry; pesticides; commercial determinants of health; public health policy; conflicts of interest; commercial practices

Contribution to Health Promotion

- Pesticides have significant impacts on health and the environment, but the pesticide industry has received limited attention as a commercial determinant of health (CDOH).
- The literature describing the scientific and political practices of the pesticide industry is broad and predominantly composed of descriptive analyses and grey literature reports.
- While the literature shows that the pesticide industry adopts practices that mirror those of other health harming industries, more empirical research is needed to examine such practices through a CDOH lens, particularly in low- and middle-income countries.

INTRODUCTION

There is growing evidence that commercial actors whose products and means of production are potentially harmful to health engage in similar practices to influence policy and science in ways that undermine population health (Brownell and Warner 2009; White and Bero 2010; Proctor 2012; Knai *et al.* 2021; Hill *et al.* 2022; Gilmore *et al.* 2023). The study of these practices forms part of a wider field of research known

as the commercial determinants of health (CDOH) (Maani *et al.* 2022; Gilmore *et al.* 2023). These are defined as the 'systems, practices, and pathways through which commercial actors drive health and equity' (Gilmore *et al.* 2023). This field of research has, to date, predominantly focused on the practices of those health harming industries (HHIs) understood to be the main drivers of non-communicable diseases (e.g. tobacco, alcohol, ultra-processed food and drinks, and fossil fuels) and related sectors (e.g. manufacturers of infant formula) (Gilmore *et al.* 2023). Yet, there is a growing need to extend analysis to incorporate the practices of other commercial actors of significance for public health, with a notable example being the pesticide industry.

Since the 1990s, frequent mergers and acquisitions have led to the development of large transnational pesticide corporations that dominate the global market (Clapp 2021). Four companies collectively account for 84% of total market share (Friends of the Earth). As of 2019, this market was valued at approximately $84.5 billion (The Business Research Company 2020). The principal players are BASF (originally founded as Badische Anilin- & Sodafabrik), Bayer-Monsanto (formerly separately Bayer and Monsanto, with Bayer acquiring Monsanto in 2018), Corteva (formerly DowDuPont), and Syngenta. These corporations exert significant influence over the entire supply chain, from research and development to production, sales, and distribution (Terwindt *et al.* 2018). This trend in industry consolidation resembles that of other HHIs. For example, 80% of the global tobacco market is held by five firms (Vital Strategies and Tobacconomics 2024), and 67% of the global beer market is owned by 10 corporations (Jernigan and Ross 2020).

Consistent with other HHIs, major commercial actors from within the pesticide industry (i.e. pesticide producers, suppliers, retailers, and their trade groups) have shifted their focus to the Global South, as regulations prohibiting the use of many highly hazardous pesticides (HHPs) have been adopted in high-income settings (Tostado and Bollmohr 2022). The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) define HHPs as:

> pesticides that are acknowledged to present particularly high levels of acute or chronic hazards to health or environment according to internationally accepted classification systems such as WHO or Global Harmonized System (GHS) or their listing in relevant binding international agreements or conventions. In addition, pesticides that appear to cause severe or irreversible harm to health or the environment under conditions of use in a country may be considered to be and treated as highly hazardous (UN Environment Programme 2024).

Pesticides and the regulation of their production and use are important from a public health perspective. Pesticides are used as part of vector-borne disease control programmes and are used extensively in many agricultural systems across the world (Food and Agriculture Organization and World Health Organization 2014). The greatest burden of the negative impacts of pesticide exposure is experienced by those living in low- and middle-income countries (LMICs) where pesticide legislation is often weak or absent (Pesticide Action Network UK 2020; van den Berg *et al.* 2020), and capacities to protect against occupational and other exposure to HHPs are often lacking (Food and Agriculture Organization and World Health Organization 2014; van den Berg *et al.* 2020). Most fatal intentional pesticide poisonings, the majority of which are associated with HHPs, occur in LMICs (Mew *et al.* 2017). Many HHPs (such as atrazine, glyphosate, and paraquat, as per the definition adopted by the Pesticide Action Network) produced in high-income countries (HICs) are banned for use in such settings because of the risks posed to health and the environment but continue to be exported to LMICs (Public Eye 2019). Exposure to pesticides through environmental pollution has been associated with adverse health impacts, including neurological diseases and cancers, and detrimental effects on fertility or pregnancy (Roberts and Reigart 2013). Globally, pesticides remain an important source of chemical pollution impacting the health of communities and the environments on which they depend (WHO 2016; Fuller *et al.* 2022).

However, despite its comparable size, influence, and significance for public health and environmental sustainability, the commercial practices of the pesticide industry have received limited attention within the CDOH field (Legg *et al.* 2021; Gilmore *et al.* 2023), and there has been no previous overview of the relevant literature from a CDOH perspective to inform the development of research, practice, and policy. To fill this gap and explore areas for future research, we conducted a scoping review to map the literature that provides accounts of scientific and political practices adopted by the pesticide industry. We also categorized the types of evidence presented for these practices to identify the knowledge and theoretical gaps in studying the pesticide industry as a CDOH.

METHODS

We employed a scoping review methodology, given the disparate nature of the literature on the pesticide industry and its practices, and the limited amount of prior work to review this literature from a CDOH perspective. We conducted the review in accordance with the Joana Briggs Institute methodology (Peters *et al.*, 2021) to describe the breadth and focus of the existing accounts. We focused on the political and scientific activities of the pesticide industry, capturing a range of document types and study designs. Our scoping review drew on an emerging typology of commercial practices described in the CDOH literature (Gilmore *et al.* 2023), which provides an important analytical tool for the identification and characterization of how commercial actors seek to influence health, policy, and science and the consequences.

Search strategy

We conducted a staged search process to identify relevant documents. We undertook a Google search with broad search terms (main company names and terms relating to strategies or tactics) to identify relevant articles and to develop a set of keywords for a full search strategy. We developed our search strategy with support from a subject librarian at the University of Edinburgh and implemented and adapted it for Scopus, Medline, Web of Science, CAB Abstracts, Policy Commons, and Global Health (CABI) (Supplementary File 1). The search terms were structured to the PCC approach (Pollock *et al.* 2023): population (pesticide industry terms or specific companies), concept (terms relating to industry strategies or tactics), and context (science or policymaking).

Scoping searches in agriculture databases (AgEcon, AGRIS, agriRxiv, Agricola) did not yield any results and these

databases were therefore not pursued further. We conducted additional searches in Google to identify relevant reports in the grey literature using similar search terms. We screened reference lists of included articles for additional studies. We also consulted experts in the fields of pesticide poisoning, CDOH, environmental health, and agriculture to identify additional relevant articles and books that present analyses of internal industry documents originating from the pesticide industry. We conducted database searches in May 2022 and updated them in August 2024. These searches were supplemented by other documents known to the study team.

Inclusion and exclusion criteria

Empirical studies, commentary/perspective pieces, reviews, books, and reports published in the grey literature were included if they provided accounts of industry practices. We applied no limit to year of publication or language. While our focus was on pesticides, documents that reported on practices by Monsanto in relation to regulation of genetically modified (GM) products were included since these products were intended to be used in conjunction with Monsanto's main pesticide product, Roundup (glyphosate) (Gillam 2017, 2021). We excluded studies that did not report on the pesticide industry or provide a detailed description of the industry's practices directed at influencing science, policymaking, or regulation. We excluded documents that described pesticide industry practices that were out of scope for the review (e.g. labour and employment rights).

Document selection

We collated all identified documents and uploaded these to Covidence (2023) for de-duplication. L.S. and M.v.S. independently screened titles and abstracts to identify eligible articles for inclusion. Potentially relevant documents were reviewed in full by L.S. and M.v.S. against the inclusion criteria. Any discrepancies were resolved through discussion to reach a consensus and reasons for exclusion were recorded. Studies not written in English ($n = 4$) were reviewed by two researchers proficient in either Spanish or Portuguese in the screening and data extraction phase (one document was subsequently included in the review).

Data extraction and synthesis

We completed a data extraction form summarizing basic characteristics (e.g. document type, data source for the document, and type of practice) for all included documents (Supplementary File 2). We did not formally evaluate the level or quality of included documents, consistent with the aims of a scoping review and previous scoping reviews (Legg *et al.* 2021). We categorized each document by the type of evidence provided for commercial practices and their impacts (i.e. whether it was descriptive or a theoretically informed empirical analysis). Data related to these practices were then extracted and grouped according to a typology of commercial practices developed by Gilmore *et al.* (2023). This typology describes seven commercial practices: political practices, scientific practices, marketing practices, supply chain and waste practices, labour and employment practices, financial practices, and reputational management practices (Gilmore *et al.* 2023). Our review focused on mapping accounts of political and scientific practices to provide initial insights into how the pesticide industry functions as a CDOH and given the importance of these practices from a public health perspective and their well-documented use by other HHIs. Focusing on a subset of practices also ensured that our review was manageable and that a comprehensive mapping of the included practices and associated literature could be performed. We also extracted evidence for reputational management practices within the included documents given the overlap of these practices with all other practices in the typology (Gilmore *et al.* 2023). The typology was used to inform the classification, grouping and presentation of the practices described in the included documents while also allowing us to identify theoretical and knowledge gaps in the literature.

RESULTS

We present the search results and screening process in a Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping review (PRISMA-ScR) flow diagram (Fig. 1). We screened 826 titles and abstracts, of which 736 were identified as irrelevant and therefore excluded. The remaining 90 full texts were screened for inclusion, of which 22 documents from database searches and nine documents identified through other sources met the inclusion criteria. In this article, we refer to all included sources ($N = 31$) collectively as 'documents' to reflect that a range of study or article types were identified by the scoping review.

Characteristics of documents

We included commentaries/perspective pieces ($n = 9$), empirical studies ($n = 8$), narrative reviews ($n = 6$), grey literature reports ($n = 4$), books ($n = 3$), and systematic review ($n = 1$). An overview of each included document and the data sources they draw on is provided in Table 1. Most of the documents ($n = 20$) described events within HICs, four in upper-middle-income countries (Brazil, Argentina, and Costa Rica), and two covering LMICs more broadly. The remaining five documents were more general, with most of the information applying to HIC contexts. Most documents described the practices adopted by Monsanto and related events ($n = 15$), while others focused on multiple companies ($n = 4$), Bayer ($n = 2$), and what was then Dow Chemical [Dow separated from DowDuPont in 2019, which then became Corteva Agriscience (Dupont 2018; Dow 2019)], Shell Oil ($n = 1$), and Imperial Chemical Industries Agrochemicals (predecessor company to Zeneca and Syngenta) ($n = 1$). One systematic review and meta-analysis focused on the pesticide atrazine (of which Syngenta is the primary producer) but did not explicitly name specific companies. This study aimed to analyse the relationship between study sponsorship, risk of bias, and research outcomes in non-human atrazine exposure studies (Bero *et al.* 2016).

In the following sections, we describe the scientific, political, and reputational practices identified in the included documents while recognizing their often inter-related and overlapping nature and effects. Additional examples are described in Table 2. The three included books (Gillam 2017, 2021; Séralini 2021) presented many detailed and thoroughly researched examples across the identified practices and expanded on some of the events described in other included documents, but additional scientific and political practices were not identified. Therefore, the below examples are drawn mostly from sources other than these books while recognizing the depth and detail they provide in addition to other published sources.

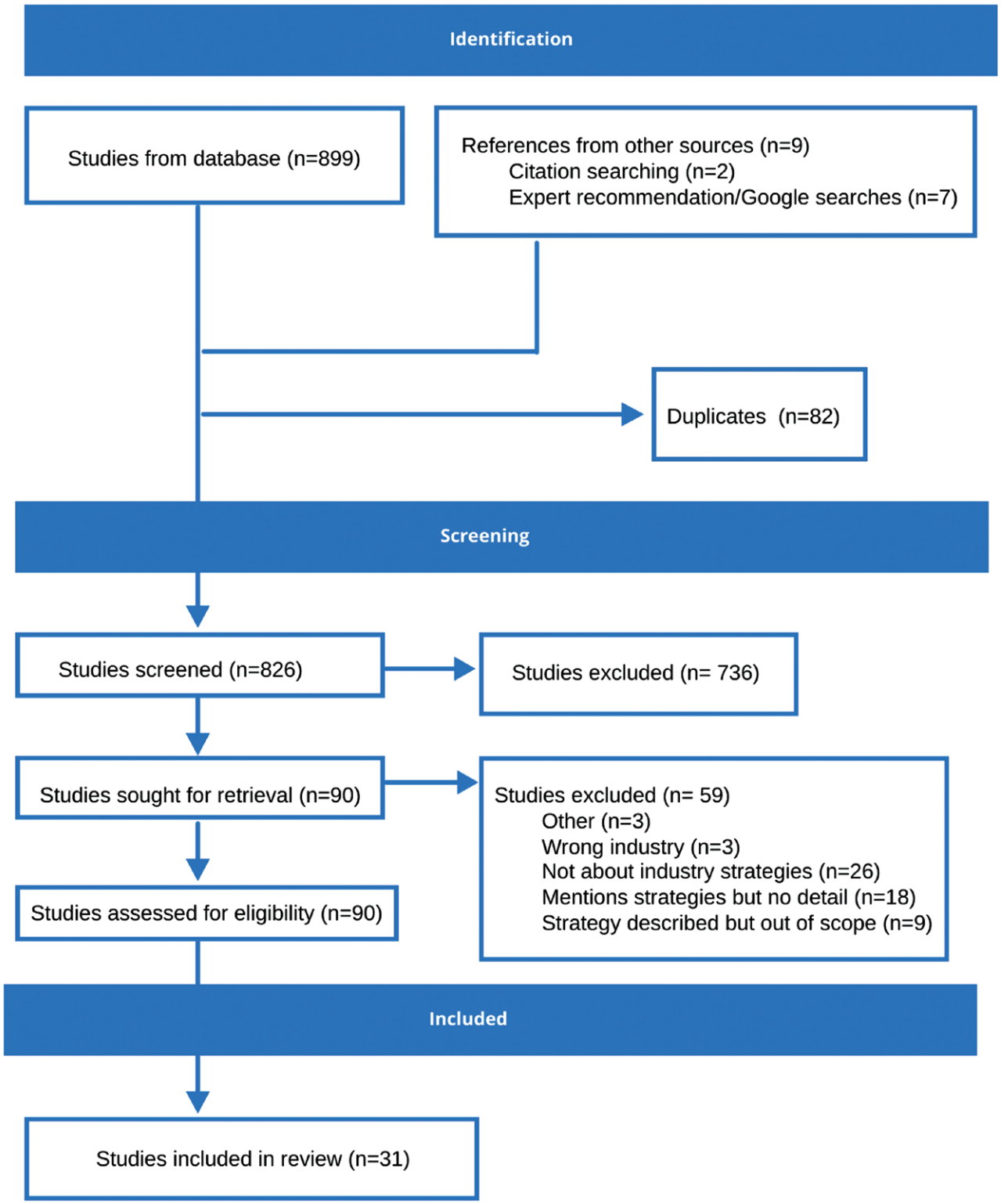

Figure 1. PRISMA diagram.

Political practices: protecting the unhindered use of pesticides

Gilmore *et al.* (2023) define political practices as 'practices to secure preferential treatment or that prevent, shape, circumvent, or undermine public policies (or a combination of the above) in ways that further corporate interests'. Included documents contained accounts of political practices adopted by major pesticide companies directed at preventing the reclassification of products and strengthening of regulatory restrictions. These included well-financed lobbying of legislators and regulatory agencies and the movement of individuals between roles as regulators or policymakers to employees of, or lobbyists for, industries affected by legislation, known as the 'revolving door' phenomenon.

Table 1. Summary of included documents.

Reference	Publication year	Setting	Company	Product	Document type	Peer reviewed	Data source(s)	Document focus
Bacon *et al.* (2023)	2023	HIC	Monsanto	Glyphosate	Empirical study	Yes	Documents made public through legal action, freedom of information (FOI) access requests, and public documents	To study how and what evidence has informed the glyphosate regulatory process in Canada
Bero *et al.* (2016)	2016	NA	Not defined	Atrazine	Systematic review	Yes	Studies published in Medline or toxicology databases	To study the impact of industry funding on results of atrazine exposure
Clapp (2021)	2021	HIC	Multiple	NA	Commentary/ perspective	Yes	NA	To give an overview of political practices and power within the food system
Corporate Observatory Europe (2022)	2022	HIC	Multiple	Pesticides, GMOs	Grey literature report	NA	European Commission (EC) documents through FOI access requests, personal communication, submissions to consultations, and EC lobby/stakeholder events	To describe lobbying activities by industry in relation to the EU 'Farm to Fork' strategy
De Olho Nos Ruralistas (2022)	2023	UMIC	Multiple	NA	Grey literature report	NA	Official meeting agendas and documents accessed through Information Access Law on meetings held between industry and government officials	To describe lobbying activities by agrobusiness think tank and companies in ministry of agriculture in Brazil as well as other ministries and relations with the sitting president
Eddleston (2022)	2022	LMIC	Imperial Chemical Industries Agrochemicals, predecessor company to Zeneca and Syngenta	Paraquat	Empirical study	Yes	Research studies (published and unpublished) and company documents	To analyse internal company documents and research studies to examine the evidence that informed the use of PP796 in paraquat SL20 and the evidence for its efficacy as an emetic and preventing death
Folguera (2021)	2021	UMIC	Bayer	NA	Empirical study	Yes	Semi-structured interviews with government officials, scientific experts, and beekeepers, document analysis of beekeeper information, government documents and scientific studies, and analysis of Bayer's website and published scientific studies (conducted and/or funded by Bayer)	To analyse framing and underlying hermeneutics about bee health
Gillam (2021)	2021	HIC	Monsanto	Glyphosate	Book	NA	Investigative journalistic analysis	An account of the lawsuit against Monsanto for glyphosate as a cause of cancer in an exposed worker, which also exposed corruption in keeping evidence of harm away from scrutiny
Gillam (2017)	2017	HIC	Monsanto	Glyphosate	Book	NA	Investigative journalistic analysis	An account of how Monsanto has engaged in corruption of science and tried to influence/silence research around the impact of glyphosate on human health

Table 1. Continued

Reference	Publication year	Setting	Company	Product	Document type	Peer reviewed	Data source(s)	Document focus
Glenna and Bruce (2021)	2021	HIC	Monsanto	Glyphosate	Commentary/ perspective	Yes	NA	To analyse internal documents showing how Monsanto engaged in ghost-writing research
Glover (2010)	2010	NA	Monsanto	GM crops	Empirical study	Yes	An analysis of Monsanto's framing of GM crops within the published literature	To conduct a framing analysis of GM crops as a solution to hunger and poverty
Goldberg and Vandenberg (2021)	2019	NA	Syngenta	Atrazine	Review	Yes	A review of published literature	To describe how industries have manufactured doubt about (among other products) pesticides
Goldberg and Vandenberg (2019)	2021	NA	Syngenta	Atrazine	Review	Yes	A review of published literature (books, peer-reviewed articles, journalistic pieces, and legal evidence)	To identify tactics used by different industries to manufacture doubt about their product
Infante *et al.* (2018)	2018	HIC	Monsanto, ACC	Glyphosate	Commentary/ perspective	Yes	NA	Influence of corporations within IARC decisions around classification of glyphosate (and meat) as possible carcinogens
Jones and Lubinski (2014)	2014	HIC	Bayer	NA	Review	Yes	Analysis of published literature and documents from corporate archives	To examine how corporate environmentalist developed within the chemical industry in West Germany
Krimsky and Gillam (2018)	2018	HIC	Monsanto	Roundup/Glyphosate	Commentary/ perspective	Yes	Discovery documents and documents obtained through FOI access requests	To review the documents released in relation to Monsanto's litigation case
Lamphere and East (2017)	2017	NA	Monsanto	Biotechnology	Empirical study	Yes	Monsanto's own produced documents on live/archived websites	To conduct a discourse analysis of Monsanto documents to understand practices the company has employed for legitimacy
Malkan *et al.* (2022)	2022	HIC	Monsanto	Roundup/ Glyphosate/ GMO crops	Grey literature report	NA	Discovery documents, documents obtained through FOI access requests, and journalistic pieces	To describe how Monsanto launched a PR strategy around glyphosate/roundup following legal cases, to busts myths about the need for pesticides, and provide practices for policy makers and scientists to
Markowitz and Rosner (2018)	2018	HIC	Monsanto	PCBs	Empirical study	Yes	Discovery documents obtained through court proceedings	To examine Monsanto documents relating to PCBs (used as pesticides), in relation to lawsuits related to non-Hodgkin's lymphoma
McHenry (2018)	2018	HIC	Monsanto	Glyphosate	Review	Yes	Discovery documents obtained through court proceedings	To examine Monsanto documents that have been de-classified to describe influence in the scientific process
Mie and Rudén (2022)	2022	HIC	Not defined	Glyphosate	Commentary/ perspective	Yes	NA	To highlight how industry held back toxicology evidence relating to glyphosate
Peekhaus (2010)	2010	HIC	Monsanto	NA	Empirical study	Yes	Interviews with communications staff at Monsanto	Monsanto's media strategy to frame themselves and their work
Pelaez and Sbicca (2003)	2003	UMIC	Monsanto	GM crops	Review	Yes	Published literature, regulatory framework documents, and news articles	To analyse the regulation process for approving GMOs in Brazil and tactic employed by pressure groups

Table 1. Continued

Reference	Publication year	Setting	Company	Product	Document type	Peer reviewed	Data source(s)	Document focus
Public Eye (2019)	2022	LMIC	Syngenta	HHPs	Grey literature report	NA	Analysis of market data	To analyse sales of HHPs to LMICs
Robinson *et al.* (2013)	2013	HIC	Multiple	Glyphosate, GM crops	Commentary/ perspective	Yes	NA	To describe conflicts of interest in the EFSA as discovered in relation to the 'Seralini affair'
Rohr (2021)	2021	HIC	Syngenta	Atrazine	Commentary/ perspective	Yes	NA	To provide an overview of controversies relating to atrazine regulation and use in the USA
Sass and Colangelo (2006)	2006	HIC	Syngenta	Atrazine	Review	Yes	Published literature and regulatory documents/reports	To review regulatory processes, government documents, and industry documents to understand influence in the regulatory process
Séralini *et al.* (2014)	2014	HIC	Monsanto	Glyphosate, GM crops	Commentary/ perspective	Yes	NA	To comment on the criticisms towards a retracted paper on the long-term toxicity of GM maize and Roundup formulation
Séralini and Douzelet (2021)	2020	HIC	Monsanto	Glyphosate	Book	NA	Investigative journalistic analysis	A description of Monsanto's campaign to influence research in relation to Eric Séralini's paper on long-term toxicity of Roundup
Thrupp (1991)	1991	UMIC	Dow Chemical; Shell Oil	DBCP	Empirical study	Yes	Interviews with plantation workers and managers, pesticide industry staff, physicians, policy officials, and lawyers, and document analysis (medical records, import data, and correspondence)	To examine a case of mass sterilization of workers in Costa Rica and its causes in relation to corporate profits
Vainio (2020)	2020	NA	Monsanto	Glyphosate	Commentary/ perspective	Yes	NA	To describe the revelations in relation to the 'Monsanto papers' (previously confidential industry documents)

ACC, American Chemical Council; DBCP, dibromochloropropane; FOI, Freedom of Information; GMO, genetically modified organism; HIC, high-income country; HHPs, highly hazardous pesticides; LMIC, lower-middle-income country; PCBs, polychlorinated biphenyls; UMIC, upper-middle-income country.

Table 2. Summary of examples of practices.

Activity	Practice	Examples
Political	Lobbying	• In their perspective piece, Clapp (Clapp 2021) reported that Corteva Agriscience, Syngenta, BASF, and Bayer AG together spent over $10 million on lobbying in the USA in 2019 • Corporate Observatory Europe (Corporate Europe Observatory 2022) reported that lobbying in the EU amounted to €6.5–7 million for Bayer and €600,000 to €3.2 million for BASF, Syngenta, Corteva, and CropLife Europe. • A report by De Olho Nos Ruralista (2022) analysed meeting records between companies involved in agribusiness lobbying in Brazil (a global agricultural superpower) and the Brazilian government. The report described registered interactions between the Ministry of Agriculture, Livestock and Food Supply (MAPA), other ministries, and lobbyists from the Pensar Agro Institute (IPA), a think tank sponsored by 48 different agribusiness associations (including pesticide companies). Among individual companies, Syngenta had the highest number of meetings for the purpose of discussing 'regulatory matters'. In addition to meetings between industry and ministers, the Brazilian President held meetings with Bayer's CEO, indicating considerable political access. Bayer also took part in meetings with officials in the Ministry of Agriculture that were not listed on official registers (De Olho Nos Ruralistas 2022). • An investigative report by Public Eye, based on an analysis of sales data and use of HHPs in Brazil (Public Eye 2019), described political pressure from the pesticide industry on technical staff to influence the re-evaluation of hazard-based cut-offs for pesticides. Syngenta was key in promoting what was referred to as the 'poison package', a bill that would remove hazard-based evaluation and make the Ministry of Agriculture responsible rather than the Ministries of Health and Environment. This shift in departmental oversight was considered to be favourable to Syngenta, as the latter would likely require stricter controls over pesticides (Public Eye 2019). • Infante *et al.* (2018) also reported that the American Chemical Council (ACC), of which Monsanto was a member, lobbied the US congress, which subsequently questioned IARC's credibility. • In another example of close engagement between members of the pesticide industry and the EPA, Sass and Colangelo's (2006) narrative review of published literature, regulatory documents and reports, describe how, unlike the EU which banned the use of atrazine in 2003, the EPA approved the continued use of atrazine in the USA. They noted that the EPA held approximately 50 meetings with Syngenta during the review period and the company was a member of the two committees that produced the recommendations on regulation of atrazine. These committees were made up of individuals from the EPA and Syngenta only, with no other organizational or public representation (Sass and Colangelo 2006). • Monsanto also funded academics to represent their interests in Hawaii, USA, where there was a proposal to restrict pesticide use. In addition to lobbying, industry-funded academics were directly involved in establishing meetings with policymakers and shaping the framing of pesticide regulations. An academic funded by Monsanto also lobbied against an EPA proposal stipulating the data requirements on the health and environmental impact of GMOs and had direct access with an EPA agent (Malkan *et al.* 2022).
	Revolving door	• Pelaez and Sbicca (2003), through analysis of published literature, regulatory documents, and news articles, explored Monsanto's efforts to introduce genetically modified organisms (GMOs) in Brazil in the late 1990s and early 2000s. This was met with resistance from consumer rights groups and Greenpeace. The authors noted that several US-based Monsanto employees were former staff within the US Food and Drug Administration (FDA), the EPA, the US Department of Agriculture (USDA), the President of the USA, Inter-government Affairs, and US Commerce. • Similarly, Rohr (2021) noted that a staff member from the consulting firm which Syngenta used was also a member of the EPA advisory board and made decisions regarding the re-registration of atrazine (Pesticide Action Network North America 2010). • In a commentary, Vainio (2020) described a relationship between Monsanto and International Life Sciences Institute (ILSI), an organization formed in 1978 by the then senior vice president at Coca-Cola and well known for its role in promoting the interests of food and agriculture industries (Sourcewatch 2021). ILSI worked to influence national and international-level pesticide policy and chaired a FAO/WHO meeting in which it was concluded that glyphosate was probably not cancerous to humans. An official report issued by the EPA's Cancer Assessment Review Committee (CARC), at the time chaired by one of its staff members, concluded, in contrast to IARC, that glyphosate is 'not likely to be carcinogenic to humans' (Vainio 2020). • In a commentary, Robinson *et al.* (2013) described the conflicts of interest that arose within the European Food Safety Agency (EFSA) in relation to the agency's work in assessing the risks associated with GM maize and Roundup (glyphosate). The chair of the EFSA management board was a long-standing member of the board of directors of the ILSI but had failed to disclose this when re-elected for EFSA. Another member of the EFSA GMO panel subsequently worked for Syngenta immediately after leaving EFSA (Robinson *et al.* 2013). • In their analysis of internal industry documents released as part of legal proceedings, Glenna and Bruce (2021) described how a former EPA staff member had taken up a position within Exponent, an organization with expertise in public relations and lobbying for chemical and plastics companies. This individual appeared to successfully lobby current EPA staff members on behalf of Monsanto, who at this time, was seeking to discredit IARC's conclusion that glyphosate was a probable human carcinogen and avoid that the EPA would adopt the same position. • In their analysis of industry documents, Krimsky and Gillam (Krimsky and Gillam 2018) examined evidence indicating that the EPA preferentially adopted regulations that aligned with Monsanto's bottom-line, which appeared to have followed engagement between Monsanto and senior EPA officials in relation to the agency's review of glyphosate. • Based on the published literature and data from corporate archives, Jones and Lubinski (Jones and Lubinski 2014) describe the chemical industry in Germany between 1950 and 1980. They suggested there were established relationships between local authorities and industry, as Bayer performed tests to assess levels of pollution despite being the source of pollution and a third party should have been responsible for performing the tests.

Table 2. Continued

Activity	Practice	Examples
Scientific	Undisclosed conflicts of interest and ghost-writing	• McHenry (2018) noted instances where the source of monetary gifts/funding obtained from Monsanto was concealed to hide its influence on debates about the IARC decision. Monsanto employees were also involved in peer review of an article that questioned the safety of glyphosate (McHenry 2018). • Krimsky specifically identified references in internal emails pertaining to the ghost-writing of a paper from 2000, which was heavily cited in the EPA's findings in 2016 as evidence to support the claim that glyphosate was 'not likely' carcinogenic. A second paper published in 2016, reviewed the evidence of glyphosate's carcinogenicity and concluded that the IARC classification was wrong. According to internal industry documents, this review was ghost written by Monsanto with the intention of influencing the European Chemical Agency (Krimsky and Gillam 2018). • Malkan *et al.* (2022) presented evidence from internal documents that a researcher hired by Monsanto to carry out genotoxicity studies had concluded glyphosate could be genotoxic and Monsanto subsequently discussed discontinuing working with the researcher as his work was not beneficial to the company. Furthermore, a 2013 paper acknowledged funding for each of the authors but failed to report that Monsanto had contributed to the content of the paper. Ghost-writing was cited as a way to 'keep costs down' (p. 24) and in an article published shortly thereafter, the authors explicitly stated that Monsanto had not been involved in the writing of the paper, a statement later revealed to be false (Malkan *et al.* 2022). • Séralini and colleagues (2014) explain that critiques of their work on long-term toxicity of Roundup-maize and Roundup formulation exposure had been reported, explicitly, as having no conflicts of interest despite being authored by employees of Monsanto.
	Attacking or influencing individual scientists and their research	• Goldberg and Vandenberg (2019) described how Syngenta recruited scientists to research the safety of atrazine. It also employed practices to discredit one particular scientist, Dr Tyrone Hayes, who became a vocal critic of atrazine and the hazard it posed by questioning his mental state, among other practices. For example, Syngenta considered the option of modifying Google searches to influence the public's access to work published by Dr Hayes (Goldberg and Vandenberg 2019). • Rohr (2021) outlined how, despite discovering that exposure to atrazine below permissible levels in drinking water caused hermaphrodism and impacted on larynx size in amphibians, Syngenta and the consulting company that hired scientists on their behalf had issued a contractual agreement that prevented Dr Hayes from publishing the findings. • Another well-documented example is related to the work of Dr Gilles-Éric Séralini, who published a paper in 2012 testing the long-term toxicity of Roundup-tolerant GM maize and a formulation of the Roundup pesticide. The findings of this paper indicated statistical evidence of a toxic impact on the livers and kidneys of rats and that exposed animals developed tumours. An article by Séralini and colleagues (Séralini *et al.* 2014) described the events that followed the publication of the paper on long-term toxicity in which Monsanto, the producer of Roundup, initiated a campaign to have the journal editor retract the paper. An article critical of Séralini *et al.*'s toxicity paper, arguing the underpinning science was flawed, was submitted by authors with links to Monsanto; yet these were not disclosed. The Séralini *et al.* paper was later retracted, despite no evidence of research malpractice (Séralini *et al.* 2014). The retraction process involved direct influence from Monsanto—shortly before the article was retracted, the journal (*Food and Chemical Toxicology*) hired a new editor for their Biotechnology section who had received funding from the agrochemical industry, including Monsanto (McHenry 2018). • Krimsky and Gillam, based on their analysis of internal industry documents, examined how Monsanto tried to conceal their involvement in the retraction and both the new editor and the editor-in-chief had received financial support from Monsanto which had not been declared at the time that the Séralini *et al.* paper was retracted in 2013 (Krimsky and Gillam 2018).
	Producing evidence to influence regulatory action	• In their examination of the framing of bee health in the Argentinian context using stakeholder interviews and document analyses, Folguera (2021) noted that industry-funded research promoting favourable results suggested that the evidence on bees was 'inconclusive'. Furthermore, their analysis demonstrated that Bayer cherry picked and promoted evidence which downplayed the risks of using insecticides and alluded to a multitude of other factors that could influence bee health. • Malkan *et al.* (2022) noted how Monsanto sought to impede a further review of the science on glyphosate by the Agency for Toxic Substances and Disease Registry (ATSDR), a department of the US Department of Health and Human Services, by requesting EPA staff to prevent a review from taking place in the USA. • Thrupp (1991) provided an in-depth account of dibromochloropropane (DBCP) exposure in banana plantations in Costa Rica, based on analysis of interviews and documents. According to their analysis, the producers of DBCP, Dow and Shell, failed to warn adequately about the toxicity of the product, the risk of harm to human health, and the measures required to prevent harm despite holding evidence from animal studies demonstrating toxic effects of DBCP exposure. In hearings about findings that workers in the USA had become sterile, the Shell scientist admitted not using correct methods to test the toxicological effects of DBCP and evidence also highlighted that Dow had suppressed information about sterility in workers in the USA and coordinated their efforts with Standard Fruit in Costa Rica, to lobby for continued use of DBCP (Thrupp 1991). • Malkan *et al.* (2022) described how research conducted by Monsanto had influenced the EU's decision to reauthorize glyphosate. For example, a European Parliament-commissioned study assessing cancer risk of glyphosate, conducted by Germany's Federal Institute for Risk Assessment, contained sections that were plagiarized from studies conducted by Monsanto (Malkan *et al.* 2022). This assessment is understood to have played a decisive role in the reauthorization of glyphosate by the EFSA. • Bacon *et al.* (2023) outlined how the regulatory process of glyphosate in Canada was skewed towards evidence produced by industry while limiting the transparency and therefore public scrutiny of this process, and that Monsanto's work to engage stakeholders to discredit the IARC statement on glyphosate as a carcinogen likely influenced both Canadian and US regulatory bodies to disregard it. • Eddleston (2022) described and critiqued human and animal-based studies undertaken by Imperial Chemical Industries Agrochemicals, the predecessor company to Zeneca and Syngenta, to test the toxicity and efficacy of the emetic PP796 in formulations of the pesticide paraquat. Some of the studies had weak designs, at times participant data was excluded from final analysis for unclear reasons, and important information was excluded from the final reporting of study results.

Table 2. Continued

Activity	Practice	Examples
	Influencing science and framing evidence	• In their comparative case study, Goldberg and Vandenberg (Goldberg and Vandenberg 2021) revealed consistencies in the ways some industries, including the pesticide industry, manufacture doubt about harms related to their products. These included attacking study design, using reputable individuals to promote industry-favourable interpretations, misrepresentation of information, hyperbolic language and influencing agencies or laws. Focusing on the documented activities of Syngenta, they identified additional tactics of suppressing incriminating information, contributing to misleading literature, hosting conferences or seminars, defining how to measure outcomes, and taking advantage of scientific illiteracy. They also posed as a defender of health/truth and obscured their involvement in research. These practices were complemented with PR strategies and attempts to influence mass media in ways that would present them in a better light. Other practices mentioned included: impeding government regulation, attacking opponents (scientifically or personally), appealing to emotion, abusing data access requests, and claiming a 'slippery slope' of catastrophic outcomes if use of the company product is reduced or banned (Goldberg and Vandenberg 2021). • Malkan *et al.* (2022) described how Monsanto, in their efforts to discredit evidence around the carcinogenicity of glyphosate, collaborated with researchers and science communicators to undermine the evidence. With regards to the latter, Monsanto and Bayer allied with science writers and communicators who authored misleading and inaccurate articles in mainstream outlets about the risk of the companies' products and without declaring their own conflicts of interest. The authors also report that despite Monsanto's internal research suggesting a cancer risk from glyphosate exposure, the company sought to influence the EPA to ensure that glyphosate was not classified as a cancer risk. According to the report, historically, scientific results were hidden or ignored by senior staff in EPA when concerns were raised about the risks associated with glyphosate (Malkan *et al.* 2022). • Glenna and Bruce (2021) presented evidence from internal emails that company executives at Monsanto were aware of studies that indicated a risk of harm and that there was a concern with ensuring the regulator was ignoring results that would be detrimental to the company (Glenna and Bruce 2021). • Palaez and Sbicca (2003) noted that to win over those opposed to introducing transgenic products in Brazil, Monsanto's Operational Director described how they would 'bring along scientists of unquestioned credibility to speak in the name of science'. However, Monsanto had to manage damaging results from their products long before the entrance of GMOs and glyphosate to the market. • Markowitz and Rosner (2018) documented how Monsanto started producing polychlorinated biphenyls (PCBs) in the 1930s and was the sole producer of the chemical. In the 1950s the company started researching the safety of PCBs and in 1955 an internally produced report noted that a mouse included in the study had developed malignant lymphoma. Yet this was not reported when publishing the results in an academic journal. The US Navy performed their own tests and found it caused both death and liver damage in animals. What followed was a campaign by Monsanto to prevent the Navy from publishing these results and efforts to label their products with minimum warning texts. There was a coordinated campaign, including directly reaching out to other researchers, to manage negative findings from studies and PR initiatives to deal with research findings perceived as threatening to Monsanto's interests (Markowitz and Rosner 2018). • Eddleston provided (Eddleston 2022) evidence for how Imperial Chemical Industries Agrochemicals, and its successor company Syngenta, promoted the use of formulations of paraquat supplemented with the emetic PP796 to improve safety despite internal understanding of the limited evidence in support of this claim and the weaknesses of its own internal studies.
Reputational management	Influencing regulatory bodies and creating narratives about working with stakeholders	• Corporate Observatory Europe (2022) described how CropLife developed a social media strategy specifically to disseminate the findings from impact studies of the EU *Farm to Fork Strategy*, and narratives signalled to policymakers that the industry is taking action to reduce the use of pesticides. One statement issued by CropLife overlooked the nuances in the Strategy and framed industry-commissioned data as holding the answers. The industry also held several sponsored events to disseminate their perspective on the *Farm to Fork Strategy* (Corporate Europe Observatory 2022). • Other examples in which policymakers have engaged more actively in reputational management activities of the industry include the issue of environmental regulation in Brazil. De Olho Nos Ruralistas (De Olho Nos Ruralistas 2022) report how Bayer produced a video in 2022 on rural insurance in which both a minister and the Director of MAPA featured. • Goldberg and Vandenberg (2019) also noted how Syngenta worked with farmers, a key stakeholder in pesticide use, to promote atrazine and warned of the undesirable consequences if this herbicide was not available. This enabled Syngenta to 'personaliz[e] the debate, allowing them to utilize farmers to perpetuate doubt'. Syngenta established a roster of stakeholders, including journalists, who they called upon to communicate with the public who were not well informed about atrazine and 'intentionally "fold[ed] atrazine into issues of broad public concern (mitigating global warming, feeding the world, biofuels)" …, thereby legitimizing atrazine as a necessary tool for human survival' (Goldberg and Vandenberg 2019, p. 356). • In Canada, the framing of evidence to support the use of glyphosate aligned with what the industry considered being acceptable evidence on which to base decision-making. While IARC based their decision on independent research, the Canadian Pest Management Regulatory Agency argued for the inclusion of studies that had been shown to be ghost-written by Monsanto (Bacon *et al.* 2023).

Table 2. Continued

Activity	Practice	Examples
	Burnishing the corporate image	• In an analysis of Monsanto's use of social media, Peekhaus (2010) outlined how the company's social media strategy centred on constituency building as opposed to responding reactively to specific events or criticism. • Malkan *et al.* (2022) detailed several practices that Monsanto employed to shape narratives around its products. Evidence from internal emails show how Monsanto and industry-funded organizations like the Genetic Literacy Project were meeting with government agencies (USDA) on projects to influence journalists, and government-funded projects such as videos promoting GMOs that carried corporate narratives (Malkan *et al.* 2022). • Monsanto also partnered with the International Food Information Council (IFIC), which describes itself as a 'nonprofit educational organization with a mission to effectively communicate science-based information about sustainable food systems' and is funded primarily through 'grants and contributions from the private sector' (International Food Information Council 2024). IFIC specifically targeted women with their messages around glyphosate and promoted experts funded or associated with the industry to provide 'the facts' about glyphosate. Furthermore, the report outlined how a whistleblower from a PR firm reported that hundreds of journalists were being tracked and flagged as potential risks to the company's reputation. The report details how Monsanto had a well-developed strategy to monitor the debate around glyphosate and adopted practices for how to respond to campaigns initiated by citizens worried about pesticides or groups like US Right to Know who filed FOIs on industry funding to academics (Malkan *et al.* 2022). • Vainio notes that Monsanto spent $17 million on PR campaigns to discredit the IARC announcement, indicating that the company was very aware that research findings and subsequent ongoing debate could have significant implications on sales (Vainio 2020).

Lobbying

Lobbying of policymakers and regulators was a key practice described within included documents. Evidence was provided by some documents for the substantial financial resources expended by the pesticide industry to lobby policymakers, both in the USA (Clapp 2021) and in the European Union (EU) (Corporate Europe Observatory 2022). Other accounts provided detailed descriptions indicating that in Brazil, a major exporter of agricultural products, the agribusiness, including pesticide companies, had access to policymakers, which allowed for lobbying on specific regulatory matters (De Olho Nos Ruralistas 2022). A report by De Olho Nos Ruralistas (2022) reported that between 2019 and 2022, a total of 160 meetings were granted to an agribusiness think tank, compared with two with farmer organizations. This indicates that industry was afforded substantially more opportunity than other stakeholders, like those representing farmers, to lobby for regulations that favoured their interests (De Olho Nos Ruralistas 2022). Another example was Malkan *et al.* (2022), a *US Right to Know* report based on analysis of discovery documents, data obtained through freedom of information (FOI) laws and investigative journalist articles. They provided an account of Monsanto's effort to influence the US Environmental Protection Agency (EPA) review of glyphosate's classification as a carcinogen. It seems that these practices were adopted in response to potential regulatory threats in the USA, arising from a 2015 ruling by the WHO's International Agency for Research on Cancer (IARC) that glyphosate, one of Monsanto's most profitable products, is a probable human carcinogen. According to the report, Monsanto representatives engaged with the EPA staff member who oversaw the agency's assessment of glyphosate as a carcinogen and authored a report concluding glyphosate is not carcinogenic (Malkan *et al.* 2022).

Revolving doors and relationships between industry and regulatory agencies

The existence of a 'revolving door' between major pesticide producers and regulatory agencies was described in several documents, including reviews (Pelaez and Sbicca 2003), analyses from the peer-reviewed and grey literature based on internal industry documents released during the discovery process of legal proceedings, corporate archives, and access to information requests (Jones and Lubinski 2014; Krimsky and Gillam 2018; De Olho Nos Ruralistas 2022; Malkan *et al.* 2022), and commentaries (Robinson *et al.* 2013; Vainio 2020; Glenna and Bruce 2021; Rohr 2021). De Olho Nos Ruralista's (2022) analysis of meeting records and data obtained through access to information requests found that Bayer's head of public affairs had worked within the Brazilian federal government before acting as a lobbyist, participating in meetings with the Ministry of Agriculture, Livestock, and Food Supply. Similarly, Malkan *et al.* (2022) described how within the US context a member of staff from the EPA left the agency to work for a public relations firm who provided services for Monsanto, only to return to working for the EPA during the Trump Administration. Another account reported that staff from consulting firms working with Syngenta also held roles within an EPA advisory board (Rohr 2021). The International Life Sciences Institute (ILSI), an organization formed by a former senior vice president at Coca-Cola, with an established relationship with Monsanto, served as chair for FAO/WHO meetings on the carcinogen classification of glyphosate.

Additionally, one document described how a member of the management board for the European Food Safety Authority (EFSA) became an employee within ILSI, then subsequently moved back to EFSA (Robinson *et al.* 2013).

Scientific practices: sowing seeds of doubt about the harm of pesticides

Scientific practices are defined as those 'involving the production and use of science to alter products or otherwise secure favourable outcomes (or both) for the industry' (Gilmore *et al.* 2023). Several scientific practices were described in the documents, including concealing of industry involvement in the scientific process, funding of industry-favourable research, attacking of threatening research and independent scientists, and framing of research findings in ways beneficial to industry.

Undisclosed conflicts of interests and ghost-writing

Some of the included documents specifically described examples of corporate involvement in the practice of 'ghost-writing' papers (Krimsky and Gillam 2018; McHenry 2018; Glenna and Bruce 2021), in particular Monsanto's efforts to discredit IARC's assessment of glyphosate as a probable carcinogen (Vainio 2020). In their analysis of internal industry documents, Glenna and Bruce, (2021) described how Monsanto's employees were contributing to the development of articles that downplayed the carcinogenicity of glyphosate but failed to disclose this involvement. Gillam (2017) presented evidence from documents released under FOI requests in which Monsanto directly solicited a group of researchers to write scientific articles promoting the safety of GM crops. However, the articles produced through this arrangement did not acknowledge Monsanto's role in influencing their content. A report produced by Corporate Europe Observatory on the EU *Farm to Fork Strategy* (Corporate Europe Observatory 2022) described how a university issued a press release about an impact study critiquing the *Farm to Fork Strategy* (which aimed to reduce pesticide use), claiming it would lower agricultural yields. The press release however failed to disclose that the study had been funded by CropLife International, a trade association made up of major agrochemical companies. Similarly, Syngenta acted to influence the debate around the *Farm to Fork Strategy* by sponsoring an opinion piece critiquing the pesticide use target proposed by the European Commission (EC). The study cited by the authors of the opinion piece to defend their criticism was not acknowledged as being industry funded (Corporate Europe Observatory 2022).

Attacking or influencing individual scientists and their research

Some of the included documents described how both Monsanto and Syngenta sought to attack and undermine the research and reputation of scientists whose work threatened their business interests. Séralini and colleagues provided the most detailed examples of Monsanto's active engagement in disputing research that went against their business interests (Séralini *et al.* 2014; Séralini and Douzelet 2021). The authors described how Séralini's own research was actively attacked by Monsanto and resulted in the retraction of a study on the effects of glyphosate despite no evidence of research misconduct. Séralini *et al.* documented the actors and processes that had contributed to the paper being retracted (Séralini *et al.* 2014; Séralini and Douzelet 2021). For example, Monsanto's involvement in the process was actively concealed presumably to avoid undermining the apparent legitimacy of the complaints about Seralini's work (Krimsky and Gillam 2018). Similar accounts were presented of Syngenta's attempts to undermine research conducted by Dr Tyorne Hayes, which suggested that atrazine had detrimental reproductive effects on amphibians even below levels permitted in drinking water (Rohr 2021).

Producing evidence to influence regulatory action

A key scientific practice described in several of the included documents was the industry's attempts to produce an industry-favourable evidence base that could be used to help it resist regulatory action. There were several such examples, including direct funding of articles that were critical of IARC and that questioned their decision to categorize glyphosate as probably carcinogenic to humans (Infante *et al.* 2018). Monsanto also produced studies that were later included in a commissioned study to assess the cancer risk of glyphosate by the European Parliament (Malkan *et al.* 2022). The impact of industry funding was also demonstrated by the selective inclusion of evidence that downplayed risks in industry-funded reports (Folguera 2021), as well as more often concluding that there is 'inconclusive' evidence of risk (Folguera 2021). Bero *et al.* (2016) studied the impact of industry funding on research findings in a systematic review of animal studies assessing the effects of atrazine exposure. Their study found that harmful effects were reported in 50% of non-industry-funded studies compared to only 18% of industry-funded studies. Industry-funded studies were also less likely to report statistically significant harmful effects (9% vs. 33% of studies funded by independent sources). Notably, 10 of the 51 studies did not disclose funding (Bero *et al.* 2016). The evidence base was also biased by avoiding the use of established toxicological methods to test for health harms from pesticide exposure. This was clear from a study examining pesticide exposure, where the producer of dibromochloropropane (DBCP), Shell, suppressed reports of sterility in USA and Costa Rican workers and their scientists admitted that correct toxicological testing had not been used. The suppression and inadequate testing allowed Shell to continue to support the use of DBCP by the Standard Fruit company in Costa Rica for over a decade (Thrupp 1991). Conversely, Eddleston provided evidence for how Imperial Chemical Industries Agrochemicals, and its successor company Syngenta, promoted the use of formulations of paraquat supplemented with the emetic PP796 to improve safety despite internal understanding of the limited evidence in support of this claim and the weaknesses of its own internal studies.

In another example, Corporate Europe Observatory (2022) analysed EC documents acquired through FOI access requests, personal communications, submissions to consultations, and EC lobby/stakeholder events related to the EU *Farm to Fork Strategy*. They described how it was evident that the industry had commissioned impact assessments that aimed to undermine the *Farm to Fork Strategy* and lobbied the EC to undertake its own impact assessment of the strategy. One of the commissioned studies was reported as having clear influence from CropLife.

Reputational management practices: protecting the 'feeding the world' narrative

Alongside the above-documented political and scientific practices, pesticide companies and their trade bodies adopted

several reputational management practices. These served to maintain their legitimacy as policy actors, as authoritative voices on the safety of their products, and to assert that the industry and its products are helping to meet the agricultural needs of the world.

Influencing regulatory bodies and creating narratives about working with stakeholders

In their efforts to influence regulatory systems, commercial actors within the pesticide industry and their trade associations sought to frame the industry as part of the solution and to promote forms of partnership working. These practices included disseminating industry-favourable framings of study results, constructing narratives that present the industry as working collaboratively to enable progress (Corporate Europe Observatory 2022), and positioning themselves as having common goals with FAO and WHO (Public Eye 2019). A report by Public Eye, an NGO that focuses on investigating and exposing human rights violations perpetuated by Swiss-based companies, described how CropLife rhetorically aligned their goal with that of WHO and FAO and claimed to be working alongside these agencies to make less toxic pesticides available on the market (Public Eye 2019). However, this obscures the ongoing export of HHPs, such as paraquat, primarily to LMICs (Public Eye 2019). One element of these practices involved building support among farmers, which enabled the industry to incorporate the issue of pesticide use into broader issues of global warming and food insecurity (Goldberg and Vandenberg 2019).

Burnishing the corporate image

Included documents described how different companies have created narratives about their products and associated harms directed at both public audiences and those within their own organizations. Many examples related to Monsanto, including partnering and funding public relations activities to specifically discredit IARC and cast doubt on their decision to classify glyphosate as carcinogenic to humans (Vainio 2020; International Food Information Council 2024). In another context, Glover (Glover 2010) described the emergence of Monsanto's framing of GM crops as 'pro-poor' and environmentally sustainable. In Germany, Jones and Lubinski (2014) described how Monsanto actively constructed and embedded a narrative about their role in supporting global food production when facing backlash from consumers in Europe against the use of GMOs. Other examples include Bayer, who in the 1970s worked on their public image to ensure they were seen as acting as a responsible company and engaged with school children to host an exhibition related to environmental protection. Internal documents discussing the thinking behind these activities showed that 'Bayer managers argued that it was necessary to engage in more active marketing efforts to counter the "industry hostility"' (Jones and Lubinski 2014, p. 639).

Other studies of Monsanto's business activities focused on their approach to biotechnology. Based on discourse analysis of Monsanto documents, Lamphere and East (2017) described how in the mid- to late 1990s, the company positioned itself as developing new technologies to meet the needs of a world in which food insecurity was framed as a key issue. This framing was used to legitimize both their restructuring of the organization and their technological developments (which included Roundup, their main pesticide product, and recombinant bovine growth hormone). In the early 2000s, Monsanto's corporate messaging reinforced these framings that had been constructed in the previous decade. Monsanto adopted what they called a *New Monsanto Pledge*, which positioned the company as contributing to sustainability. The authors, however, argued that the language used did not necessarily indicate a pledge for action but reflected Monsanto's narrowly constructed framing of the issue to normalize and legitimize the use of technology as the only option to achieve sustainability. Moreover, Monsanto presented itself as part of the solution and aligned its framing with wider sustainability and human rights policy agendas (Lamphere and East 2017).

DISCUSSION

This scoping review provides a mapping of the literature describing the commercial practices of major pesticide companies to influence science and policymaking. Collectively, the included documents represent a valuable body of evidence for how the pesticide industry has acted to influence understanding of the harms associated with its products and to block, delay, or weaken attempts to restrict the (re)licensing and use of pesticides. This has been achieved through well-characterized and synergistic practices that function to subvert scientific, policymaking, and regulatory processes while maintaining the industry's social licence to practice in the interest of maximizing commercial gain but at the expense of public health. The activities described paint a picture of an industry that has engaged in a range of practices, across time and place, to produce an industry-favourable evidence base, including the direct of funding research and impact assessments, ghost-writing of manuscripts, interfering in the peer review process, and actively discrediting the research of academics and organizations such as IARC whose activities threaten industry interests.

Beyond influencing the production of knowledge, the industry has engaged in shaping the *use* of evidence by policymakers and regulatory agencies and other institutions like the EC and their decision-making functions, including withholding of internal evidence for the harm associated with their products. The industry and its representative trade bodies have acted to establish themselves as legitimate partners in the production of evidence and policy and as playing a positive role in ensuring safe use of pesticides and the creation of sustainable agricultural systems. Coupled with the existence of revolving doors between the industry and regulatory bodies in multiple contexts, and the embedding of industry-favourable norms and practices related to the assessment and use of pesticides, these practices have helped in establishing policy and regulatory systems that are highly amenable to the interests of the pesticide industry.

These documented practices are highly consistent with those of other HHIs, such as the tobacco, alcohol, unhealthy food and beverage, fossil fuels, lead, and asbestos industries, which have cast doubt about the harms of their products and disarmed attempts to restrict their commercial activities: from the distorting and misuse of science to the influencing of the academic process, policymakers, regulatory bodies, and public perceptions and understanding (Markowitz and Rosner 2002; Tweedale and McCulloch 2008; Knai *et al.* 2018; Lauber *et al.* 2021; Legg *et al.* 2021; Carvalho *et al.* 2022; Gilmore *et al.* 2023; Ulucanlar *et al.* 2023). This gives further support to previous scholars who have called into question

the tendency to treat commercial actors differently because they produce products with divergent implications for health and the environment (Hawkins *et al.* 2018; Knai *et al.* 2021; Hill *et al.* 2022). It signals the need for a comprehensive conceptualization of how commercial practices and products impact health beyond a narrow focus on those industries that manufacture particular consumer products associated with non-communicable diseases. The findings of this review make a clear case for the CDOH community to afford the pesticide industry the same level of attention that has been traditionally directed at other HHIs. Indeed, more recent studies included in our review, such as Bacon *et al.* (2023), suggest a growing recognition among scholars of the need to apply a CDOH lens to the pesticide industry including to its engagement with policymakers, regulatory agencies, and researchers.

Most accounts of the pesticide industry's practices were provided by commentaries and comprehensive investigative reports published in the grey literature, as well as a limited number of empirical, theoretically informed studies explicitly designed to describe and critique these practices as structural determinants of health and equity. Investigative journalists and advocacy organizations have been instrumental in exposing and describing the practices of the industry. The state and focus of the literature reflect the availability of internal industry documents released during the discovery process of legal proceedings in the USA, which have proved an invaluable source of evidence for how this industry operates to shape science and policy in ways conducive to its interests. Much of the literature therefore describes events and commercial practices related to Monsanto and Syngenta as main producers of the pesticide glyphosate-based Roundup and atrazine, respectively, which have been at the centre of much of this ligation.

As a scoping review of an under-researched CDOH, we adopted a narrow focus on the practices employed by the pesticide industry to shape science and policymaking and the related practice of reputational management. While it was limited to these practices and did not involve a full systematic review of the literature or critical interpretive analysis of the extracted data, by including a range of document types it provides informative insights into the set of practices used by the pesticide industry to shape science and policymaking and the state of the literature documenting these. Use of a published typology enabled us to map and describe these practices from a CDOH perspective; however, challenges remain with regards to allocating some practices to specific categories or type. This reflects the considerable overlap between the scientific, political, and reputational management practices adopted by commercial actors and the functions they serve (Gilmore *et al.* 2023; Ulucanlar *et al.* 2023).

Future research

Our scoping review helps to illuminate topics and contexts that require analysis from a CDOH perspective. For example, HHPs are recognized as common means for suicide (Mew *et al.* 2017), and restricting access to HHPs is a cost-effective intervention to prevent suicide by pesticide poisoning (Lange *et al.*, 2024). Simultaneously, the industry has acted to promote alternative approaches favourable to their commercial interests, such as 'safe storage' practices (Konradsen *et al.* 2007). Yet, we did not identify a body of literature examining the pesticide industry's attempts to shape suicide prevention research and policy agendas of governmental and non-governmental organizations. Similarly, we did not identify literature analysing the industry's activities in the context of other policy agendas of critical importance to both health and the industry's commercial interests, such as the proceedings of the FAO and WHO Joint Meeting on Pesticide Management (Food and Agriculture Organization and World Health Organization, 2024; World Health Organization 2024) or the implementation and review of the Rotterdam Convention (Secretariat of the Rotterdam Convention 2024), an international treaty that aims to govern international trade, and environmentally sound use of, particular hazardous chemicals. Future research could focus on building greater understanding of how the pesticide industry engages with such bodies and systems of policymaking as well as other developments, such as synergies between the policy practices of the pesticide industry and the commercial priorities of other industries of relevance to health, such as major food producers and the growing cannabis industry (Subritzky *et al.* 2017; Orenstein and Glantz 2020). More attention should also be directed at studying the industry's ongoing efforts to shape understanding of and policy responses to emerging effects associated with exposure to their products, notably the potential risk of Parkinson's disease and threats posed to bees and other pollinators. Additional studies are needed to map and review the literature that describes and analyses the pesticide industries' marketing, supply chain and waste, labour and employment, and financial practices, which were beyond the focus of this scoping review.

Most importantly, the majority of the studies identified by our review described industry activities in HICs. Those who are at greatest risk from the activities of the pesticide industry are under-represented in the literature included in this review and few studies consider the industry as a driver of inequities. Much more focus is needed on the practices adopted by the pesticides industry in LMICs that are most affected by, and dependent on, the industry's products and practices. This finding is consistent with other's assessment of the CDOH evidence base and the need for more analysis of industry practices in LMIC settings (Abdalla *et al.*, 2022). This dearth can be considered particularly significant in the context of pesticides given the distinctive combination of an inequitable distribution of global health impacts, striking divergence in regulation and greater exposure to much more hazardous products, banned for use in HICs but manufactured and exported to countries in the Global South.

Implications

While the scoping review reveals avenues for future research, the findings have clear implications for policymakers and regulatory agencies, as well as the academic, public health, and advocacy communities. The totality of evidence presented here reinforces previous calls for transformational reforms to address industry influence of policymaking and the functioning of regulatory agencies to protect such processes from undue industry influence and maintain their independence, including the establishment of robust and effective governance systems for engaging with industry (Baur *et al.* 2019; Moynihan *et al.* 2019; Mialon *et al.* 2020; Reed *et al.* 2021). As Reed *et al.* (2021) discuss, major changes are urgently needed to shift the outsized influence that commercial actors have on health policymaking and governments should be held to account for failing to counter harmful commercial practices. At a minimum, greater transparency of the lobbying practices of the pesticide industry could be facilitated

through the establishment of comprehensive lobbying registers. However, such a measure alone will be insufficient and wider system and governance changes are needed to address the power imbalances that exist in the policymaking space between the ability of those who are harmed by pesticide exposure and those who profit from weak regulation and ubiquitous use of pesticides.

Transformational changes are needed to ensure the independent functioning of agencies that regulate pesticides and other forms of chemical hazards and pollution to ensure the protection of public health, particularly among vulnerable populations. Woodruff *et al.* (2023) have proposed five overarching principles and scientific recommendations to guide the use of science across all areas of chemical exposure, hazard, and risk assessment to prevent and minimize public health impacts. These include measures to shift away from the use of industry-favourable assumptions and logics, including the assumption that there exists a 'safe' or 'no-risk' level of chemical exposure in the general population, shifting the financial burden of data generation for any given chemical onto the producers that benefit from their (re)introduction onto the market, and mandating that hazard and risk assessments evaluate and account for financial conflicts of interest (COI) in the evidence base. Similarly, the findings presented above also re-affirm the need for much stronger measures to protect research from industry influence and maintain academic independence (Baur *et al.* 2019). For example, Baur *et al.* (2019) put forward key principles for safeguarding the integrity of research in occupational and environmental global public health. The first of these emphasizes the pressing need to strengthen COI declaration policies to cover financial and other forms of relationships with relevant industries, and penalties for inaccurate disclosures, to protect peer review journals, peer review panels, and government entities (a necessary but insufficient measure). The second calls for maintaining high ethical standards within academic and other related institutions, and the third for governments to ensure the availability of independent funding sources for research. The fourth principle describes the importance of protecting the decision-making process from COIs and ensuring that research evidence used to inform policy is evaluated against criteria set by an independent scientific community, and not the industry being assessed. Finally, measures must be taken globally to restore dignity in academic publishing (Baur *et al.* 2019). In seeking to address such concerns, there is clear scope to draw on experiences of developing and implementing norms, rules, and policy tools to effectively minimize tobacco industry interference in public health policy (Ralston *et al.* 2021, 2022), to manage conflict of interest in nutrition policy (Ralston *et al.* 2021), and emergent tools to support more effective and accountable engagement with private sector actors (WHO 2024).

CONCLUSIONS

The pesticide industry is made up of major global corporations whose products and practices have considerable impacts on human health and the environment. However, there is a clear need for further research on the practices of the pesticide industry, particularly in relation to the industry's attempts to shape policy developments in LMICs and at the international level across a range of issues, and to assess the implications for health and the environment. This scoping review provides an initial mapping of the literature on some of the industry's practices that can serve as a foundation for future research agendas to study the pesticide industry from a CDOH perspective. The importance of adopting such a perspective is becoming ever apparent given the pressing need to identify effective ways to achieve global health, equity, and environmental sustainability goals.

Supplementary Material

Supplementary material is available at *Health Promotion International* online.

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Conflict of interest

M.Pea. is a member of the International Association for Suicide Prevention (IASP) and a Co-Chair of the Special Interest Group Prevention of Intentional Pesticide Poisoning. D.G. has been a co-applicant on AFSP funding awards and grants. D.G. was an (unpaid) expert adviser to WHO's First Consultation on Best Practices on Community

Action for safer access to pesticides (Geneva, 2006). He was an (unpaid) expert adviser to WHO's Consultation on cost-effectiveness of suicide prevention interventions, including pesticide regulation (Geneva, 2019). D.G. drafted and provided technical assistance for the development and publication of a WHO resource tool for 'Suicide prevention: a resource guide for pesticide registrars and regulators' (WHO, May–June 2019) and received a small grant for this work. D.G. was a member of the scientific advisory group for a Syngenta-funded study to assess the toxicity of a new paraquat formulation (2002–06); a member of the scientific advisory group for a pesticide storage project funded by Syngenta (2005–07); and chaired the data monitoring and ethics committee (DMEC) for a Syngenta-funded trial of the medical management of paraquat poisoning (2007–10). D.G. received travel costs to attend research and DMEC meetings of the Syngenta funding studies, but no other fees. D.G. was Former Samaritans trustee (2015–18) and a member of Samaritans Policy and Research Committee (2015–21), Movember's Global Advisory Committee (2019–22), Department of Health (England) National Suicide Prevention Strategy Advisory Group, and IASP (all unpaid roles). M.v.S. is on the Editorial board at Health Promotion International. M.v.S. was a guest editor on the CDoH special issue published by Health Promotion International. M.P. is on the Advisory Board of Health Promotion International. None of the authors were involved in the review process or in any decision-making on the manuscript. R.B. and M.E. have nothing to declare.

Data availability

All data used in this study are in the public domain

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