

## Pharmaceutical residuals in water: social challenges and opportunities for upstream mitigation measures in home setting

Anne-Claire Maurice\*<sup>1</sup>, Cyrille Harpe<sup>2</sup>, and Elodie Brelot<sup>3</sup>

<sup>1</sup> *Laboratoire Environnement, Ville, Société (EVS), Institut National des Sciences Appliquées (INSA), Lyon, France*

<sup>2</sup> *Département Santé Environnement Travail et génie sanitaire, Ecole des Hautes Etudes en Santé Publique (EHESP), Rennes, France*

<sup>3</sup> *Groupe de recherche, animation technique et information sur l'eau (GRAIE), France*

### KEYWORDS

Pharmaceuticals in water – wastewater – survey – qualitative study – health care professionals – ethnographic approach.

### ABBREVIATIONS

HAH: Hospitalization at Home

### ABSTRACT

In recent years, the diversity of pharmaceutical residuals found in aquatic environments has raised concerns. Different paths have been proposed to reduce their presence. However, there are still uncertainties on which strategies, upstream or downstream, preventive or technical, global or local, should or could be applied. Among them is the classification of certain pharmaceutical treatments as requiring specific attention and precaution measures, including collecting patients' body substances containing pharmaceutical residuals. This study assessed the existing status of patients' excreta, examined the social barriers and solutions for limiting pharmaceutical residuals emissions through an upstream strategy. We used ethnographic (n=57) and quantitative (n=428) approaches among health professionals. Body substances were associated with taboo, and subject to recommendations in health sectors. Among field workers, attitudes of reluctance, skepticism, but also openness towards collecting body substances emerged. Health managers' views were biased towards wastes from non-consumed pharmaceuticals. Currently, European regulation offers limited opportunities for effective measures. Encouraging the reanalysis of public health and environmental concerns together emerges as a promising path regarding pharmaceutical residuals.

## 1 INTRODUCTION

In recent years, the diversity of pharmaceutical residuals found in aquatic environments raised concerns. Globally, the first source of emission is by far excretion of consumed pharmaceuticals. Most studies focused on health institutions, further contributing to portray hospitals as the major source of emissions. However, taking apart their social role of norm and some very specific active pharmaceutical ingredient mainly administrated by these institutions, most hospitals were identified in average as a low source contributing to the total charge of pharmaceuticals in wastewater. Indeed, excretion of residues occurs among all human population (Ort et al., 2010). This non-point source contamination (diffuse source) is further increased by recent politics consisting of shortening stay of patients in hospitals and encouraging treatment (and following period of excretion) at home. Some residues in particular raise concerns for scientists or civilian representatives, such as antibiotics (Ben et al., 2019, Minguez et al., 2016) or chemotherapy (Johnson et al., 2008), either for human health or other species. If part of the charge in pharmaceutical residues may be decreased by encouraging better use of drugs or non-pharmaceutical options, many conditions will still require pharmaceutical treatment. Yet, few studies investigated possible upstream options to deal with this major diffuse source of contamination by pharmaceutical residues from body substances.

Different paths have been proposed to reduce this non-point contamination in water. One option is wastewater treatment but cost and technical challenges remain before being efficient and widely implemented (De Andrade *et al.*, 2018; Angeles *et al.*, 2020). Another path is environmental classification of pharmaceutical treatments, which has been initiated by different parties and is regularly discussed (Lockwood and Saïdi, 2017). Among environmental scientists and stakeholders in France emerged the proposition that identifying some of them as requiring specific attention and precaution measures, including collecting patients' body substances (urine, excrement, sweat) containing pharmaceutical residuals, could contribute to resolve the issue. This would mean targeting some treatments, according to their duration and active molecules, and thus involving health professionals and patients in the process. Lienert et al. (2011) evaluated the relevance of different collecting solutions for medication residues in hospital setting with a multicriteria method, where it was decided not to evaluate the option of a systematic collection of excreta. However, collecting excreta remains an option for medication that would be identified as a high risk through environmental risk assessment required by regulation agencies (CHMP, 2006). Several studies evaluated the willingness of ambulant patients from Radiology departments to collect urine (Diels *et al.*, 2015; Lyko, Klepiszewski. and Venditti, 2015). More positive results than expected were observed, but underlined the importance of health professional involvement. Yet, to our knowledge no studies analyzed in details attitudes of health professionals in home care and managers regarding this option. While demonstrating a risk from pharmaceutical residues in waters to human health is extremely challenging, long term and cocktail dose exposition effects are possible and it thus is critical to investigate solutions limiting their occurrence.

In this study, we assessed health professional's knowledge and attitudes related to pharmaceutical residues emission in particular at home and through patients' excreta. We examined social barriers and potential solutions for limiting these discharges through an upstream strategy.

## 2 METHODS

### 2.1 Ethnographic approach of home care waste management

Nurse and care assistants are professions that have a particular connection with pharmaceutical residuals. Their activities are directly related to their source, being unconsumed pharmaceuticals, soiled material or patient's excreta. In France, nurses constitute the largest group among health professionals, and they are more likely to enter in the domestic context. They may in particular intervene in HAH. In France, HAH frequently requires a high level of medical equipment of patient's home, which we hypothesized could be of importance for a procedure of collecting excreta for specific treatments at home. HAH also uses cytotoxic drugs, currently the only pharmaceuticals recognized as dangerous for the environment in French law<sup>1</sup>.

In order to approach the existing statuses of pharmaceutical residues and patients' excreta, and difficulties and potentials regarding their elimination, we adopted an inductive approach for material collection and analyses borrowing methods and concepts of ethnography and sociology of technics (Akrich, 1998; Toussaint and Vareilles, 2019). In 2016-2017 we conducted a qualitative study in France (Maurice, 2017) focused on nurses and health care assistants, paying a particular attention to objects and practices surrounding pharmaceutical residues from home care as well as the network they were embedded into.

Interviewees recruitment occurred in three steps: (1) exploratory phase with semi-structured interviews of various health professional related to home care, following a convenient strategy; (2) an instrumental case study (Stake, 1995) in a pilot territory (Bellecombe site) (see Maurice, 2017); with maximum variation sampling based on professional activity; (3) an investigation among professionals of interest at the national level with a purposeful strategy based on criterion sampling (Palinkas *et al.*, 2015). At the pilot site, our starting point was a Hospital at home (HAH) service (20 beds), dispensing and coordinating health care provided by out-of-hospital nurses as well as hospital nurses from this service. Semi-structured interviews (n=35) were conducted with staff from this service and from other services intervening in outpatient care and from independent nurses; they were triangulated with participant observation during staff's rounds and office-based handovers for six weeks. Interviews continued until saturation (De Sardan, 1995).

A consent form was provided to the patients visited with the health professionals. Personal agreement for recording was asked at the beginning of each interview. Interviews were totally anonymized regarding patients and as much as possible regarding professionals. A total of 57 interviews were conducted and transcribed. Independent nurse interviews were coded in a multi-thematic approach (Ayache and Dumez, 2011).

Anthropological studies may examine perceptions about the future, but their interest is generally more embedded in present or past. However, a few authors advocated for an anthropology of "anticipation", arguing that current technologies constantly modify our perceptions, and favor the imbrication of the future in the present, which may in turn drive changes (Abélès, 2003). With this perspective, we explored attitudes towards a possible collection of excreta in home care.

Principal topics of the interviews were: material mobilized in HAH, usage and perception of objects allowing collection of wastes and excreta, pharmaceutical drug management at home. The interviews ended with a projection exercise consisting in anticipating conditions of a hypothetical procedure of excreta collection at home.

## 2.2 Large-scale surveys of health professional managers

Following our qualitative approach, we conducted in 2017-2018 an intervention towards current and future health professional managers enrolled in the French School of Public Health. We introduced the issue of pharmaceuticals in waters to these professionals with high responsibilities in the French health care system (see Maurice, 2017b for detailed methods). Prior communication of information, we evaluated their knowledge and attitudes towards pharmaceuticals in water, and solutions proposed by experts to limit this contamination. One goal of the survey was to identify predictors of attitude regarding collecting excreta of patients. Based on our ethnographic approach, the principal hypothesis was that perceived control would predict a more positive attitude towards collecting excreta.

The survey was followed by a presentation of an education kit and a collective discussion. Interventions occurred at the end of a mandatory course, limiting the auto-selection bias ( $n=428$ ). Training programs surveyed were: hospital engineers (technical and scientific duties, may be in charge of equipment, risk management); directors of nursing care (mostly nurses), managers of a social and health-care centers (working mainly in hospitals or retirement homes), directors of Health and Social Affairs and public health professionals (engineers, physician, pharmacist inspectors).

We borrowed from the theory of planned behaviour (Ajzen, 1991) the principle that behaviors are determined by factors including perception of control on this behavior. However, we focused on the description of attitude towards a procedure (collecting excreta) that remains very hypothetical at this stage.

### Questionnaires

Details of the questionnaire are described in Maurice (2018a). Among the constructs measured were knowledge of wastewater treatment (recoded as binary variables); perception of: the presence of pharmaceuticals in water in environment in general, treated wastewater, food and drinking water; human health risks<sup>2</sup> related to these presences (eight 7-point Likert items); importance of different sources (Fig. 1); relevance of various solutions identified by experts (Fig. 2); perceived control on release of pharmaceuticals in water in professional setting (acting directly or indirectly in favor of an upstream solution: a procedure of separation of excreta in institution/at home, specific waste management coordination for non-consumed pharmaceuticals, and raising awareness of patients/professionals; five 5-point Likert items).

### Statistics

Descriptive statistics were calculated on all respondents. Identification of factors associated with attitude regarding collecting excreta of patients was performed among most represented professional groups i.e. directors and hospital engineers ( $n=314$ ), also the most concerned by the option of collecting excreta. Individuals with missing data were excluded ( $n=43$ ). A Principal Component Analysis was conducted to verify the number of dimensions. Dimensions identified were: health risk (4 items), perceived control on an excreta procedure (2 items), presence of residues (4 items), individual sources (2 items: patient excretion and medicines thrown in the sink or toilets), professional sources (3 items), knowledge of wastewater fate (2 items). Internal consistency was verified with Cronbach alpha for each dimension identified before computing its mean. Multivariate analysis was performed, with the response variable being the attitude regarding collecting excreta of patients. Proportional odd assumptions were verified graphically (Harrell, 2015), and met for all variables except promotions. We computed a cumulative logit model with proportional odds assumption relaxed for promotions (Agresti, 2019) using VGAM package from R-software. False discovery rate correction was used to control for the proportion of type I errors (Verhoeven, Simonsen and McIntyre, 2005). Explanatory variables included were: age, sex, promotion (reference category: director of health care entering promotion) and scores on the dimensions previously identified.

### 3 RESULTS & DISCUSSION

#### 3.1 Insights from the ethnographic approach

Here, we propose that adequate articulation of professional and private spheres rises challenges both at the material and organizational dimensions that may affect how health professionals apply standards of hospital rules regarding waste management and ultimately medication residues. “Action’s programs” (Akrich, 1993) of domestic and professional objects and procedures telescopes with each other. This yields to adaptations of the hospital procedures, primarily however under the initial framework: formal rules and organization of care at home are designed mostly for health objectives, and markedly under economic logics. Pro-environmental behaviors seem then largely dependent on individual sensitivity.

##### 3.1.1 *Complexity of logistics and limits of waste management in hospitalization at home*

Hospitalization at home may require a complex logistics and because of the multiple conditions of homes and geography, resists to standardization, including regarding retention of medication residues by health care professionals. Material and organizational aspects already limit sorting of health wastes that are not related to excreta. In HAH setting, face to face interactions are concentrated in a short window of time as the patient is far from health professional staff, and family collective, who may take a large part in providing care, also need attention. Moreover, while in hospitals the organization of materials is well incorporated by the professional, in HAH each home is a new environment where standardization of tasks must occur. Sorting of wastes, last in the list of tasks, encounter higher risks of being overlooked according to interviewees.

Similar limits occur for independent nurses in their independent activity. This activity depends largely on a pricing system by gradual decrease of nursing acts reimbursed by the national healthcare insurance in a given visit. In addition, nurses pay for eliminating properly their health care wastes. Accumulating short visits may thus be financially more rewarding than accumulating tasks in a single visit and navigating from home to home with bulky equipment and wastes. Non-remunerated extra tasks are accepted by independent nurses, but mostly for patient comfort. Several interviewees insist that a protocol of body waste management would require a payment. If current health care waste management is theoretically regulated by the law, this regulation is in fact not well incorporated in the practices.

Both hospital and independent nurses work with non-adapted vehicles (professional or personal), not equipped with a separation for “clean” and “dirty” material. Independent nurses usually tolerate only transportation of sharp wastes. The largest HAH interviewed (>1000 beds), implanted in a metropole area, managed to negotiate that its material furnisher took charge of the activity of care waste retrieval. A similar organization could be considered for excreta management.

##### 3.1.2 *Pharmaceutical residues representations in home care*

Few health care professionals are familiar with the concept of pharmaceutical residues in water, except through media coverage of birth control pills traces. They are however more talkative about “rests” of medications in proximal human environment.

A preoccupation is limiting medication consumption, which matches objectives of promoting prevention, limiting undesired health problems arising from overmedication as well as limiting waste of public funds. However, at the same time, medication and its stocking is also used in health care at home as well as in retirement homes to organize work, contributing to a “material rationalization” (Carricaburu, 2005). “*We try to resolve the problem immediately [through a prescription] so as not to have to come back to it later*” explains a nurse who discusses situations where prescription is made in anticipation and would technically not be for sure necessary.

Another non ecocentric preoccupation relates to specific residues for sanitary motives: radio-pharmaceuticals and cytotoxic drugs residues. Abroad, certain health institutions have produced guides to inform health care professionals and patients about chemotherapy residues excretion (e.g. in UK,

Australia). In France, such guides exist but are rare, and their recommendations seldom applied. Health care professionals interviewed were poorly aware of the excretion paths. Besides, those guides highly present water as a mean to evacuate the risk (recommending flushing twice, washing sheets etc.). The invisible residue is here treated in the same way as unused medicines: older nurses expressed the fact that throwing medication in the sink or toilet used to be an action to avoid a risk (e.g. inadvertent poisoning of surrounding children). In 2015 the Food and Drug Administration still recommended to eliminate medication rests in the toilets, for safety reasons. Presence of residuals in excreta is considered in professional recommendations, but seen as a danger for proximal environment (relatives, caregivers) that is important to evacuate. This preoccupation could be an opportunity to draw attention towards risks to the environment more generally.

### **3.1.3 Current body waste management**

In the HAH studied, higher degree of isolation of professionals when visiting a home encourage further the task shifting from medical doctors to nurses, and nurses to care assistants. This shift already observed in hospitals is further encouraged by the perception of care requiring excreta proximity and/or manipulations as a “dirty work” (Arborio, 2012). Thus, according to the interviewees, body waste management is taken in charge by care assistants more than in hospitals. A similar observation emerges among independent nurses who prioritize tasks judged more technical<sup>3</sup> than hygiene care. Boring or embarrassment attitudes arise from nurses when mentioning excreta management, except for dressing change which may require higher technicity, on which are constructed claims of professionalization.

Care assistants would thus be a key actor of information of the patient, but they do not have knowledge legally recognized in terms of pharmaceuticals. This would require establishing new “mediation chains” (Akrich, 1996) by recognition and share of pharmaceutical competency domain with them. An alternative would be to re-include excreta management as an aspect of nursing work. A valorization either financial or recognizing a professional competence (technicity of the task) would help improve the acceptability of such a protocol.

### **3.1.4 Separating patient's excreta in home care setting: heterogeneous attitudes**

Among field workers, we could identify three types of attitudes emerging in relation towards the idea of separating patient's excreta: reluctance, skepticism, but also openness, which may be concomitant in some interviewees.

Openness is usually related to the proximity with practices that marginally exists for self-centered (medical analyses), altruistic or environmental purposes (radiology protocols). Openness also depended on environmental awareness of the interviewee.

Skepticism and reluctance may be related to an economical, material and humanistic apprehension of the problem. Health care wastes management rules are dictated by health risks management and economic rationalizations. Professionals acknowledged in different contexts non-planned practices in an effort to limit the costs of health care wastes (e.g. a nursing teacher reporting teaching students to pour medication infusion bags in the sink). Environmental preoccupations from health activities are more focused on “material waste” (development of a “sense of economy”) rather than chemical pollution. Reluctance is also of course based on extra work that would be necessary to convince and explain to the patient a collecting procedure. They also insist on vulnerabilities either financial, health-related or psycho-sociological many patients already face (e.g. decrease in quality of life). Besides, even current objects for collecting excreta do not appear well adapted to home use, subject to ergonomic and practical problems. Bedpans, commodes or urinals are usually in the domestic bedroom, materializing autonomous loss and affecting patient's dignity. Taboo also seems present, refraining professional talking about this aspect of patient life considered out of the framework of the professional management.

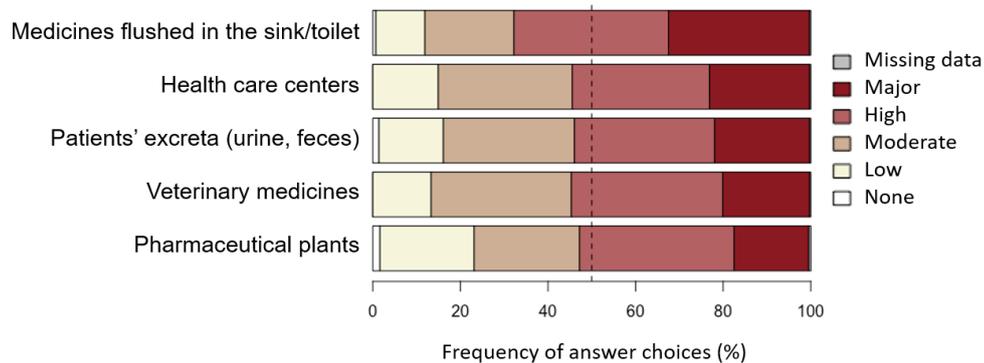
If body substances are associated with a classical taboo, i.e. as body wastes, they would reach a supplementary degree of material impurity (Douglas, 1998) in the recognition of what could be designated as the perception of a chemical “dirt”. The relation of the nurse with a patient seen as someone to heal and to care enter in contradiction with the figure of a person as a source of contamination. This reluctance to acknowledge residues in excreta seem more specific of the independent nurses, whose relations to patients are also described as submitted to a “client” perspective. Many independent nurses worried that managing and thus recognizing this impurity would put a stigma on the patient. Many felt that approaching excreta of patients as a risk of contamination would be a “dramatization”, considering the contribution to the collective risk to be low relatively to the individual cost. Moreover, if the situation now improved, professionals complained that for different reasons, patients are not all entirely aware of the nature of their treatment, in particular when chemotherapies, nor of its risks. The gravity of the treatment being perceived as a heavy burden to carry is one of the reasons, and health care professional expressed concerns that mentioning excreta residues would generate patients’ anxiety.

Finally, many health care professionals pointed out the role of hospital and directors in managing this issue. We thus completed our study with an intervention among health professional managers and future managers.

## 3.2 Health professional managers survey

### 3.2.1 Knowledge of wastewater treatment and perceptions on source contamination

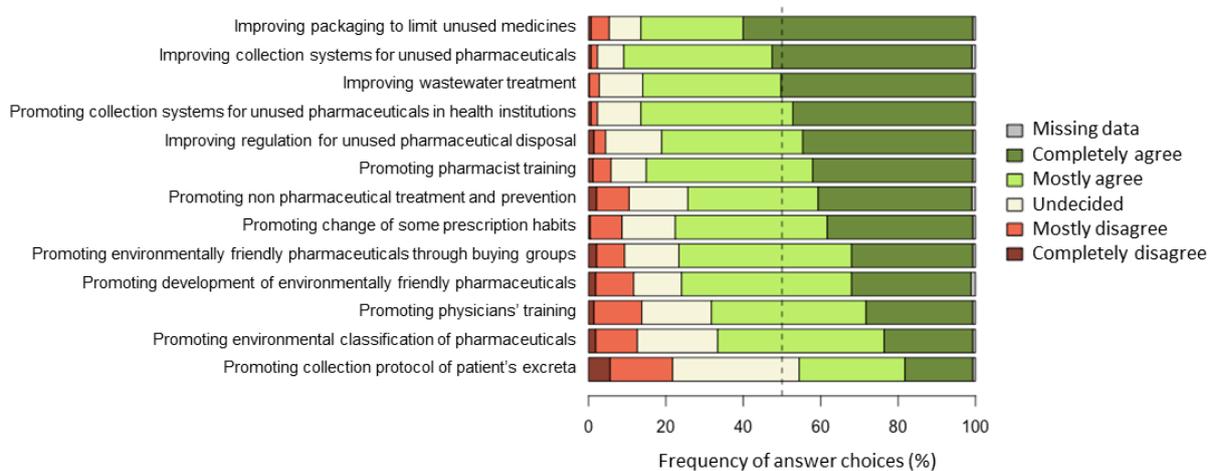
Overall, knowledge of respondents was not optimal. Only 13% of respondents knew that wastewater treatment plant (WWTP) in France are not equipped to treat pharmaceuticals. Regarding their primary origin, in average, professionals designated medication drugs thrown in the sink or toilets as the most important contributions (strong or major, 68% of respondents) more than other sources, including human excretion (fig. 1). The results converge with previous observations among general public regarding unused medications but differs slightly regarding excretion. Excretion was rarely considered a major source by individuals from the general population in Malta and Ireland (Fenech *et al.*, 2013) or Germany (Götz *et al.*, 2019), while across all respondents in the present study it was not seen very differently than plant, veterinary or health institutions sources. A plausible explanation from our field study is that recurrent campaigns to raise awareness about unused medicines contributed to make it perceived as an important source of environmental contamination. In terms of pollution units, studies showed that pharmaceutical plants were the strongest local sources; however, it was the source the most frequently designated as weak in our sample of health professional managers (21.5%). This is different from German population which designated it in average as the most important (Götz *et al.*, 2019). As stated by Götz *et al.*, risk perception is highly associated with benefits’ perception. This is particularly true in health culture with benefit/risk balance being at the core of pharmaceutical authorization, use, and thus production.



**Figure 1. Perception of the contribution of five sources of pharmaceutical residues in water (n=428). Dashed line represents 50 %.**

### 3.2.2 Attitudes regarding expert's options for limiting pharmaceuticals in water

Overall, all solutions were judged relevant, with an exception (fig. 2): excreta sorting rose most of negative attitudes with 22% disagreeing. However, 33% were undecided regarding excreta sorting, suggesting that support for this option could be gained. Most positive answers were related to unused medicines (e.g. improving packaging or collection systems), in agreement with the overall perception of unused medications thrown in the sink or toilets as an important source of residues. This bias could be a consequence of many education campaigns for proper medication sorting.



**Figure 2. Perception of the relevance of 13 solutions for limiting pharmaceutical residues in water (n=428). Dashed line represents 50%.**

Perception of control regarding excreta collection procedure was higher among health care directors (42% in health institution and 20% at home) followed by institutions directors (hospital: 37% and 14%, health care and social institution directors: 33% and 10%). This means that directors felt more confident about their possibility to act, converging with perceptions of health fieldworkers that designated them as key actors (see 2.1.). On the contrary hospital engineers felt much less confident about their opportunity to act directly or indirectly (20% and 11%).

As expected, perception of a higher indirect or direct control was the only and a strong predictor of positive attitude regarding excreta collection (OR=2.57;  $p < 0.001$ ). During group sessions, directors

from health and social care institutions in particular expressed a more positive view on their control for action.

In conclusion, it would be possible to improve knowledge of health professionals' workers and managers. This improvement could encourage local initiatives for limiting pharmaceutical release in wastewater. A distortion of perceptions regarding the source of pharmaceuticals in water towards unused pharmaceuticals need a particular attention, with better coordination between campaigns focused on unused medication program and those on pharmaceutical in waters. Finally, interventions for raising awareness must adapt to health professionals and consider their lack of perceived control; support to a procedure consisting in collecting excreta could be gained, but it is important to demonstrate its feasibility and proportionality.

## Conclusions

Based on fieldworkers and managers' data, we found that pharmaceuticals in water are in many ways invisibles, although they are subject to recommendations to avoid risks in proximal environment. This invisibility is sustained by a lack of integration of environmental objectives in health care objects and contexts. It seems associated with a lack of knowledge but also with difficulties for health professionals to introduce environmental perspectives in the structuration of health organization and patients and caregiver relationships. Health professionals were reluctant to the option proposed by environmental scientists and stakeholders of collecting patients' excreta.

From the literature and targeted interviews, we observed that European regulation regulatory set up is currently superficial in the opportunities offered to introduce measures at the patient level for limiting pharmaceuticals to be released in the environment (Maurice, 2018b). Possible measures in guiding documents are of a narrow scope (consisting in simple mentions in the pharmaceutical product documentation). Moreover, evaluation of environmental risk is far from being systematically evaluated in existing drugs.

Encouraging the reanalysis of public health concerns together with environmental concerns regarding pharmaceutical residuals – generalizing the concept of “One health” – emerges as a promising path.

## Acknowledgements

We thank all the respondents for their time, P. Di Majo, the HAH staff and contacts of the Sipibel pilote site and EHESP for their organizational help; J.-Y. Toussaint and S. Vareilles for their advice.

The RILACT project was co-funded by the Rhone-Mediterranean and Corsica Water Agency and the French Biodiversity Agency.

## References

- Abélès, M. (2003) "Anthropolis, revue d'anticipation culturelle", *Journal des anthropologues*, (92–93), pp.295–297. <http://jda.revues.org/2151> (Accessed: April 10, 2017).
- Agresti, A. (2019) *An introduction to categorical data analysis*. 3rd editio. Wiley.
- Ajzen, I. (1991) "The theory of planned behavior", *Organizational Behavior and Human Decision Processes*, 50(2), pp.179–211. doi: 10.1016/0749-5978(91)90020-T.
- Akrich, M. (1993) "Les objets techniques et leurs utilisateurs, de la conception à l'action", in *Les objets dans l'action*, Editions de l'EHESS, pp.35–57. <https://halshs.archives-ouvertes.fr/halshs-00081731> (Accessed: August 12, 2020).
- Akrich, M. (1996) "Petite anthropologie du médicament", *Techniques & culture*, 25–26, pp.129–157. doi: 10.4000/tc.511.
- Akrich, M. (1998) "Les utilisateurs, acteurs de l'innovation", in *Éducation permanente*. Éducation. Arcueil, pp.79–90.
- De Andrade, J.R. *et al.* (2018) "Adsorption of Pharmaceuticals from Water and Wastewater Using Nonconventional Low-Cost Materials: A Review", *Industrial and Engineering Chemistry Research*, pp.3103–3127. doi: 10.1021/acs.iecr.7b05137.
- Angeles, L.F. *et al.* (2020) "Assessing pharmaceutical removal and reduction in toxicity provided by advanced wastewater treatment systems", *Environmental Science: Water Research and Technology*, 6(1), pp.62–77. doi: 10.1039/c9ew00559e.
- Ayache, M. and Dumez, H. (2011) "Le codage dans la recherche qualitative une nouvelle perspective?", *Le Libellio d'AEGIS*, 7(2), pp.33–46. <http://crg.polytechnique.fr/v2/aegis.html#libellio> (Accessed: September 5, 2020).
- Ben, Y. *et al.* (2019) "Human health risk assessment of antibiotic resistance associated with antibiotic residues in the environment: A review", *Environmental Research*, pp.483–493. doi: 10.1016/j.envres.2018.11.040.
- Carricaburu, D. (2005) "De la gestion technique du risque à celle du travail : l'accouchement en hôpital public", *Sociologie du travail [Online]*, 47(2), pp.245–262. doi: 10.4000/SDT.26412.
- Committee for medicinal products for human use (2006) *Guideline on the environmental risk assessment of medicinal products for human use*. London.
- Diels, J. *et al.* (2015) *Getting a grip on drug residues in our waters A report on a source-oriented approach to drug residues in our waters*. Zwolle, Netherlands. [www.wdodelta.nl/grip](http://www.wdodelta.nl/grip) (Accessed: August 27, 2020).
- Douglas, M. (1998) "La pureté du corps", *Terrain*, 31, pp.5–12. doi: 10.4000/TERRAIN.3131.
- Fenech, C. *et al.* (2013) "Attitudes towards the use and disposal of unused medications in two European Countries", *Waste Management*, pp.259–261. doi: 10.1016/j.wasman.2012.12.018.
- Götz, K. *et al.* (2019) "Risk Perception of Pharmaceutical Residues in the Aquatic Environment and Precautionary Measures", in *Management of Emerging Public Health Issues and Risks*. Elsevier, pp.189–224. doi: 10.1016/b978-0-12-813290-6.00008-1.
- Harrell, F.E. (2015) *Regression Modeling Strategies*. Second. Cham: Springer-Verlag. doi: 10.1007/978-3-319-19425-7\_14.
- Johnson, A.C. *et al.* (2008) "Do cytotoxic chemotherapy drugs discharged into rivers pose a risk to the environment and human health? An overview and UK case study", *Journal of Hydrology*, 348(1–2), pp.167–175. doi: 10.1016/j.jhydrol.2007.09.054.
- Klatte, S., Schaefer, H.-C. and Hempel, M. (2017) "Pharmaceuticals in the environment – A short review on options to minimize the exposure of humans, animals and ecosystems", *Sustainable Chemistry and Pharmacy*, 5, pp.61–66. doi: 10.1016/J.SCP.2016.07.001.
- Lienert, J. *et al.* (2011) "Multiple-criteria decision analysis reveals high stakeholder preference

to remove pharmaceuticals from hospital wastewater”, *Environmental Science and Technology*, 45(9), pp.3848–3857. doi: 10.1021/es1031294.

Lockwood, S., Saidi, N. and Saïdi Nada (2017) “Background document for public consultation on pharmaceuticals in the environment”, (September), pp.1–90.

Lyko S., Klepiszewski K. and Venditti S. (2015) “Reducing emissions of pharmaceutical residues to surface waters by implementing measures of source segregation”, in *Interreg IV-B-NWE project partnership 2012-2015, noPILLS report*. Essen, Germany: EmscherGenossenschaft, pp.70–80. [http://www.no-pills.eu/conference/BS\\_NoPills\\_Final\\_Report\\_long\\_EN.pdf](http://www.no-pills.eu/conference/BS_NoPills_Final_Report_long_EN.pdf) (Accessed: August 27, 2020).

Maurice, A.-C. (2017) *Soin en ville et rejets de résidus de médicaments dans les eaux : hypothèses de projection pour une meilleure captation*. Villeurbanne.

Maurice, A.-C. (2018a) *Diffusion de supports pédagogiques sur le thème des résidus de médicaments dans les eaux : enquête sur les perceptions de cadres et futurs cadres en santé*. Villeurbanne.

Maurice, A.-C. (2018b) *Médicaments à usage humain et risque environnemental : synthèse d'options réglementaires pour faciliter la mise en place de nouvelles mesures d'atténuation*. Villeurbanne.

Minguez, L. *et al.* (2016) “Toxicities of 48 pharmaceuticals and their freshwater and marine environmental assessment in northwestern France”, *Environmental Science and Pollution Research*, 23(6), pp.4992–5001. doi: 10.1007/s11356-014-3662-5.

Ort, C. *et al.* (2010) “Determining the fraction of pharmaceutical residues in wastewater originating from a hospital”, *Water Research*, 44(2), pp.605–615. doi: 10.1016/j.watres.2009.08.002.

Palinkas, L.A. *et al.* (2015) “Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research”, *Administration and Policy in Mental Health and Mental Health Services Research*, 42(5), pp.533–544. doi: 10.1007/s10488-013-0528-y.

De Sardan, J.P. (1995) “La politique du terrain. Sur la production des données en anthropologie”, *Enquête. Archives de la revue Enquête*, (1), pp.71–109. doi: 10.4000/enquete.263.

Soyer, M. and Gauthey, J. (2018) *Lutter contre les micropolluants dans les milieux aquatiques : quels enseignements des études en sciences humaines et sociales ? (32)*, *Le portail technique de l'OFB*. Agence française pour la biodiversité. <https://professionnels.ofb.fr/fr/doc-comprendre-agir/lutter-contre-micropolluants-dans-milieux-aquatiques-quels-enseignements-etudes> (Accessed: September 6, 2020).

Toussaint, J.-Y. and Vareilles, S. (2019) “Politiques environnementales et changements techniques: éléments de réflexions pour une mise en œuvre effective.” *Les éditions en environnements VertigO*. doi: 10.4000/VERTIGO.27370.

Verhoeven, K.J.F., Simonsen, K.L. and McIntyre, L.M. (2005) “Implementing false discovery rate control : increasing your power”, *Oikos*, 108, pp.643–647.

## Footnotes

<sup>1</sup>Ministère des affaires sociales et de la santé, 2016. Pour une bonne gestion des déchets produits par les établissements de santé et médico-sociaux.

<sup>2</sup> We focused on health related risk, which is frequently the first considered (Soyer and Gauthey, 2018) whereas still under investigation (Klatte, Schaefer and Hempel, 2017).

<sup>3</sup> Only 2 out of 11 private practices declared taking in charge hygiene care.