



ORIGINAL ARTICLE

Healthy worker, healthy citizen: the place of occupational health within public health research in Switzerland

I. Guseva Canu¹ · M. François¹ · H. Graczyk^{1,2} · D. Vernez¹

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Abstract

Objectives To assess the state of Swiss occupational health (OH) research over the period 2008–2017.

Methods Two types of indicators were constructed, focused, respectively, on resources available for OH research and its output. Data for their assessment were gathered from specialized research institutions, professional associations, and the Swiss Federal Statistical Office.

Results Thirty-two of 317 Ph.D./M.D.–Ph.D. theses delivered were in the field of OH. The number of OH physicians progressed substantially, but the density of OH professionals per number of active workers showed important variations between OH disciplines and geographical regions. The number of yearly peer-reviewed publications increased substantially but represented 6% of publications in public health in 2017. Psychological and respiratory health conditions were the most studied topics, while papers on cancers accounted for only 10%.

Conclusions This study suggests a limited place of OH research in the Swiss public health landscape and the need for a national research effort in OH. This requires an improved collaboration between regional and federal authorities and communication/coordination between public health authorities and OH executive institutions belonging to the economic sector.

Keywords Occupational epidemiology · Research monitoring · Indicator · Exposure sciences · Environmental epidemiology

Introduction

The International Commission on Occupational Health (ICOH) defines the aims of occupational health (OH) as: “the promotion and maintenance of the highest degree of physical, mental, and social well-being of workers in all occupations; the prevention among workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; the placing and maintenance of the workers in an occupational environment adapted to their physiological and psychological capabilities; and, to summarize, the adaption of work to man and of each man to his job” (ICOH 2012). Public health, which aims to protect and promote health at population level, naturally encompasses OH (Bauer and Hämmig 2014).

Switzerland is a country of workers: around 60% of the population participate in professional activities (OFS 2018a, b). Consequently, OH should be present within public health frameworks and represent an important area

Since the 1st January 2019, the Institute for Work and Health (IST) merged with the University Medical Policlinics, the University Institute of Social and Preventive Medicine, and the Canton of Vaud Association for Health Promotion to form unisanté, the Center for Primary Care and Public Health, University of Lausanne, Switzerland, where IST became the Department of Occupational and Environmental Health (DSTE).

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✉ I. Guseva Canu
irina.guseva-canu@chuv.ch; irinacanu@hotmail.com

¹ Center for Primary Care and Public Health (unisanté), University of Lausanne, Biopôle, Route de la Corniche, 2, 1066 Epalinges-Lausanne, Switzerland

² Public Health Service, Canton de Vaud, Avenue des Casernes, 1014 Lausanne, Switzerland

of public health research and intervention. In practice, health protection and promotion are delegated to the Swiss National Accident Insurance Fund (SUVA) and the State Secretariat for Economic Affairs (SECO), in charge of the application of insurance law and labour law, respectively. These executive bodies, however, have no academic mission, and no OH research body exists at national level. Historically, Switzerland was among the first European countries to adopt legislation protecting workers' health. Nowadays, it is the only member country of the International Labour Organization (ILO) that has not ratified Convention N°187 "*Framework for promotion of health and safety at work*." It has also neglected the regular review of its occupational disease list (Graczyk and Guseva Canu 2018).

A 2006 report on OH in Switzerland concluded that it was lagging behind other European countries when it came to OH university-level training and research, and that dedicated resources were insufficient (Bauer et al. 2006). Since then, there has been no systematic evaluation of the topic and little is known on the current state of Swiss OH research. Traditionally, two standardized indicators, i.e. statistical data on work accidents and occupational diseases, help to drive OH research and evaluation of OH measures. However, they are inadequate to characterize the state of OH from the academic point of view, since OH research involves a greater variety of disciplines than public health research does and implies a strong multidisciplinary interplay between epidemiology, exposure, and biological and medical sciences (Online resource 1). Therefore, our objective was to construct specific indicators to assess the state of Swiss OH research and its development over the past 10 years.

Materials and methods

Indicators for assessing the state of occupational health research within public health research

To quantify the state of OH research, we elaborated two types of indicators. The first one focused on OH research output, such as the number of scientific peer-reviewed publications, overall and stratified by related disciplines. The second one focused on OH human resources available, such as the number of specialists in OH and related disciplines able to participate in or to lead research projects. To assess the place of OH research within public health, these indicators were compared to their public health equivalents whenever possible. To evaluate the dynamic of OH research, we followed these indicators yearly from 2008 to 2017 and compared them with those for the period 1998–2007 whenever possible.

Sources of data and data collection

As our main source of data, we have chosen to use institutional records from university repositories. The first reason motivating this decision was that a number of journals in OH (particularly in the exposure science) are not indexed in Medline; therefore, sourcing bibliographic data from PubMed would have resulted in an underestimation of the number of articles published. The second reason was that we wanted to evaluate the place of OH within the main academic public health institutions. Indeed, when OH research takes place within these institutions, it gives OH more visibility as a public health issue.

From the list of partner institutes and universities of the Swiss School of Public Health (SSPH+), which encompasses all academic institutions in the field of public health in Switzerland, we identified institutions with a primary research focus on public health or OH. The inclusion criteria for selection were historical importance, capacity to participate in or lead research in OH and related disciplines, and data availability regarding scientific output and numbers of professionals trained to doctorate level (Ph.Ds and M.D.–Ph.Ds). Six institutions were selected: the Institute for Epidemiology, Biostatistics and Prevention in Zurich (EBPI), the Institute for Social and Preventive Medicine in Bern (ISPM), the Institute of Global Health in Geneva (IGH), the Institute of Social and Preventive Medicine (IUMSP) and the Institute for Work and Health (IST) in Lausanne, and the Department of epidemiology and public health from the Swiss Tropical and Public Health Institute in Basel (EPH-Swiss TPH). To gather data on OH specialists, we contacted the following professional associations: FMH, the Swiss Medical Association and the Swiss Society of Occupational Medicine (occupational physicians), the Swiss Society for Occupational Hygiene (hygienists), and the Swiss Ergonomics Association—SwissErgo (ergonomists). We asked for the official number of qualified specialists, their geographical location, and available historical data. The Swiss Federal Statistical Office (OFS 2018a) provided numbers of employed workers overall and by regions.

Data management and analysis

From the selected institutions' online repositories, we downloaded all peer-reviewed publications from 2008 to 2017. We applied the same bibliographic research method, described in Online Resource 2, whatever the institutions database considered. All institutes but the IGH has dedicated library staff, which we contacted to check the completeness of records for the period 1998–2017. All

librarians contacted have confirmed that the databases are objectively up to date and complete for the period 2008–2017. We thus limited our study to the period 2008–2017, for which all institutions had equally complete records.

Papers included had at least one author from the selected institutions; we did not disaggregate or weight data by authorship rank. Consequently, they cover all research activities by the selected Swiss institution-based researchers. Research populations or laboratories where the research data originated were not necessarily based in Switzerland.

To evaluate *the proportion of OH and exposure science in public health research*, we identified within each bibliographic database articles with a focus on 1—exposure science (occupational and/or environmental), 2—occupational health, 3—occupational epidemiology, and 4—environmental epidemiology. We chose to include environmental epidemiology and exposure science papers as the scientific knowledge, training, and processes used to assess and control environmental, and workplace hazards are relatively similar (Harper et al. 2015; Yassi and Kjellström 2011). We excluded editorial articles such as letters to the editor, commentaries, and responses. Papers describing clinical, observational, or intervention research protocols or research methodology in occupational medicine were classified as OH.

Within the exposure science category, we classified articles according to the hazard(s) studied. For occupational epidemiology papers, we considered both hazard(s) and associated health conditions and effects. The category of health conditions and effects captures effects not recognized as clinical diseases (e.g. stress, burnout, pre-clinical effects). This analysis was carried out on the consolidated bibliographic corpus of the six institutions (including the IST) and on the IST data alone. Analysis on the IST data was extended over two periods: 1998–2007 and 2008–2017.

To evaluate the numbers of public health professionals trained during the 2008–2017 period, we considered the number of Ph.D. and M.D.–Ph.Ds graduates and the proportion of OH or exposure science theses. Data were obtained from the university online repositories and cross-referenced with information on the institutes' websites, when available.

To make sense of the data regarding OH professionals, we elaborated additional indicators to compare Switzerland to other countries or to target indicators from policy papers. One such indicator was the number of active workers per occupational physician, calculated globally and by region.

Results

Research output in exposure science, occupational epidemiology, and occupational medicine

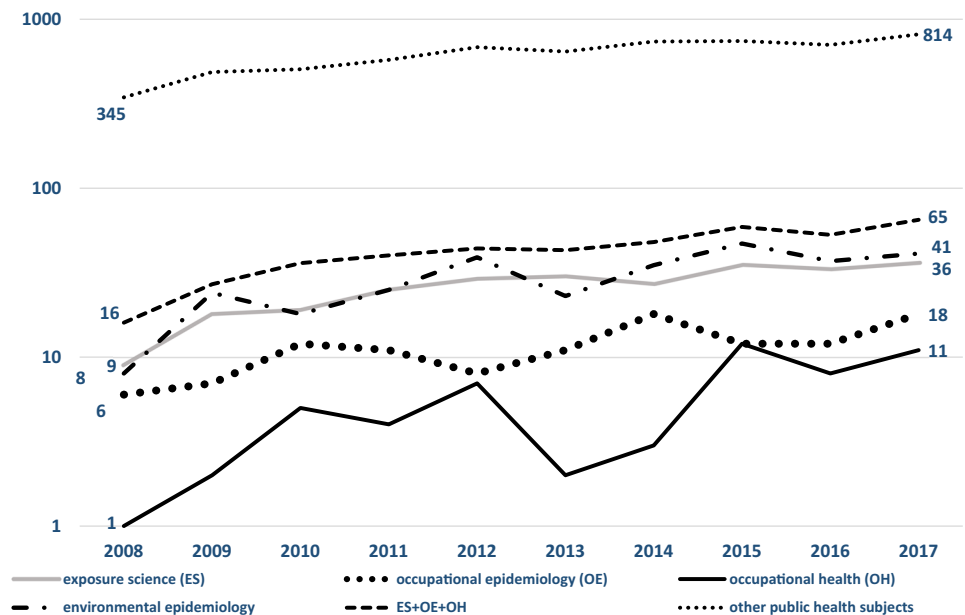
From 2008 to 2017, the number of yearly peer-reviewed publications in the four defined categories has increased substantially: + 300% for exposure science (from $n = 9$ to $n = 36$), + 200% for occupational epidemiology (from $n = 6$ to $n = 18$), + 1000% for occupational health (from $n = 1$ to $n = 11$), and + 400% for environmental epidemiology ($n = 8$ in 2008, $n = 41$ in 2017) (Fig. 1). This growth mirrors the increased output in public health research over the same period and correlates with an increase in the number of articles published by the IST between 1998–2007 and 2008–2017, from around 100 articles (Online resource 3) to more than 200. Considering yearly publications' number for all other public health subjects, the increase was 136% ($n = 345$ to $n = 814$). In proportion to overall publications, exposure science, occupational epidemiology, and OH articles have increased their share: from around 5% at the beginning (4.3% in 2008, 5% in 2009) to more than 6% during four of the last 5 years of the period (6.1% in 2013, 6.9% in 2015, 6.7% in 2016, 7.1% in 2017).

During this period, the institutions studied have published 6968 peer-reviewed articles. Exposure science, occupational epidemiology, and OH papers represent 6.2% of all publications, environmental epidemiology articles 4.3%. The proportion of papers published in these four subjects is very high at the IST (84.9%). Among the other institutions, only the EBPI and the EPH-Swiss TPH have a proportion of publications in these subjects equal or higher than 5%, respectively, 5.2% and 20.6% (Fig. 2). Overall, the relative place of OH and related disciplines in public health research has grown significantly during the period studied but remains modest in comparison with the total output in public health research.

Hazards and health conditions studied

The hazards studied in exposure science are predominantly hazards related to measurable pollutants and stressors, i.e. chemical and physical hazards. Considering the six institutions together and the IST alone, exposure science publications studying them represent almost 50% of all papers, respectively, 42.5% and 45.8% (Fig. 3). Exposure to fine and ultrafine particles (air pollution, engineered nanoparticles, other particles) represents a second focus of these studies: they amount to 34.8% of all publications, 38.2% for the IST (Fig. 3) where the proportion of exposure

Fig. 1 Evolution of the number of yearly publications in public health, occupational health and its related disciplines, and environmental epidemiology in the six selected Swiss public health institutions in Switzerland, 2008–2017



science articles on nanomaterials is particularly high (33.1%). Compared to the 1998–2007 IST data (Online Resource 4), the increased proportion of exposure science papers on nanoparticles is remarkable (2% in 1998–2007). Conversely, the number of papers on particles appears to decrease over time (17% during 1998–2007 and 5.1% during 2008–2017), highlighting a shift of focus in particle research.

In occupational epidemiology articles, the profile of hazards studied is slightly different with the emergence of a hazard almost absent from the exposure science category: psychosocial hazards. A third of articles published in the six institutions, and almost a quarter of the IST articles focused on them (Fig. 3). In contrast, they were the subject of only one IST publication from 1998 to 2007 (Online Resource 4). Chemical and biological hazards are well represented while physical hazards take the back seat: they are studied in less than 10% of papers overall and only slightly more at the IST. The importance of nanomaterial exposure studies does not translate to a similar level of occupational epidemiology studies, less than 2% overall (Fig. 3). The two most studied health conditions are psychological and respiratory conditions. The proportion of papers on cancers is around 10%, both for all institutions and IST.

Quantifying the occupational health research workforce

From 2008 to 2017, the selected institutions delivered 317 doctoral and M.D.–Ph.D. theses; thirty-two were in the field of exposure science, OH, or occupational epidemiology (Online Resource 5). More than half (18) were

completed at the IST. In 2017, there were five theses in these disciplines out of 33 theses (Fig. 4).

From 2008 to 2017, the number of occupational health physicians (OHPs) has increased from 90 to 134 (+ 48.9%) (Online Resource 6) while the employed working population went from 4,443,000 to 5,010,000 (+ 12%). The density of OHPs (average number of employed workers per one physician) has thus evolved from one OHP for 49,256 employed workers in 2008 to one per 37,388 in 2017 (Table 1).

Differences in density between regions are important: while the Lake Geneva and Central Switzerland regions have a density of around one OHP for 20,000 active workers, the Ticino region has one OHP for 87,000 active workers. In four regions, representing almost 60% of the total employed populations, the density of OHPs is lower than the national average.

Physicians specialized in prevention and public health (PPHPs) possess the required skills and competencies needed for OH research. In 2017, 70 were registered as active. Between 2008 and 2017, their number has increased only slightly from 62 to 70 (+ 12.9%) (Online Resource 6).

Occupational hygienists are highly skilled professionals who undergo specialized postgraduate training after a master degree in natural sciences, medicine, or toxicology. Consequently, they have the potential to engage in OH research. We estimated the number of active occupational hygienists to be 87 in 2017 with an average density of one occupational hygienist per 53,287 active workers. Again, differences between regions are important: while the Lake Geneva region has one occupational hygienist per 21,622 employed workers, the

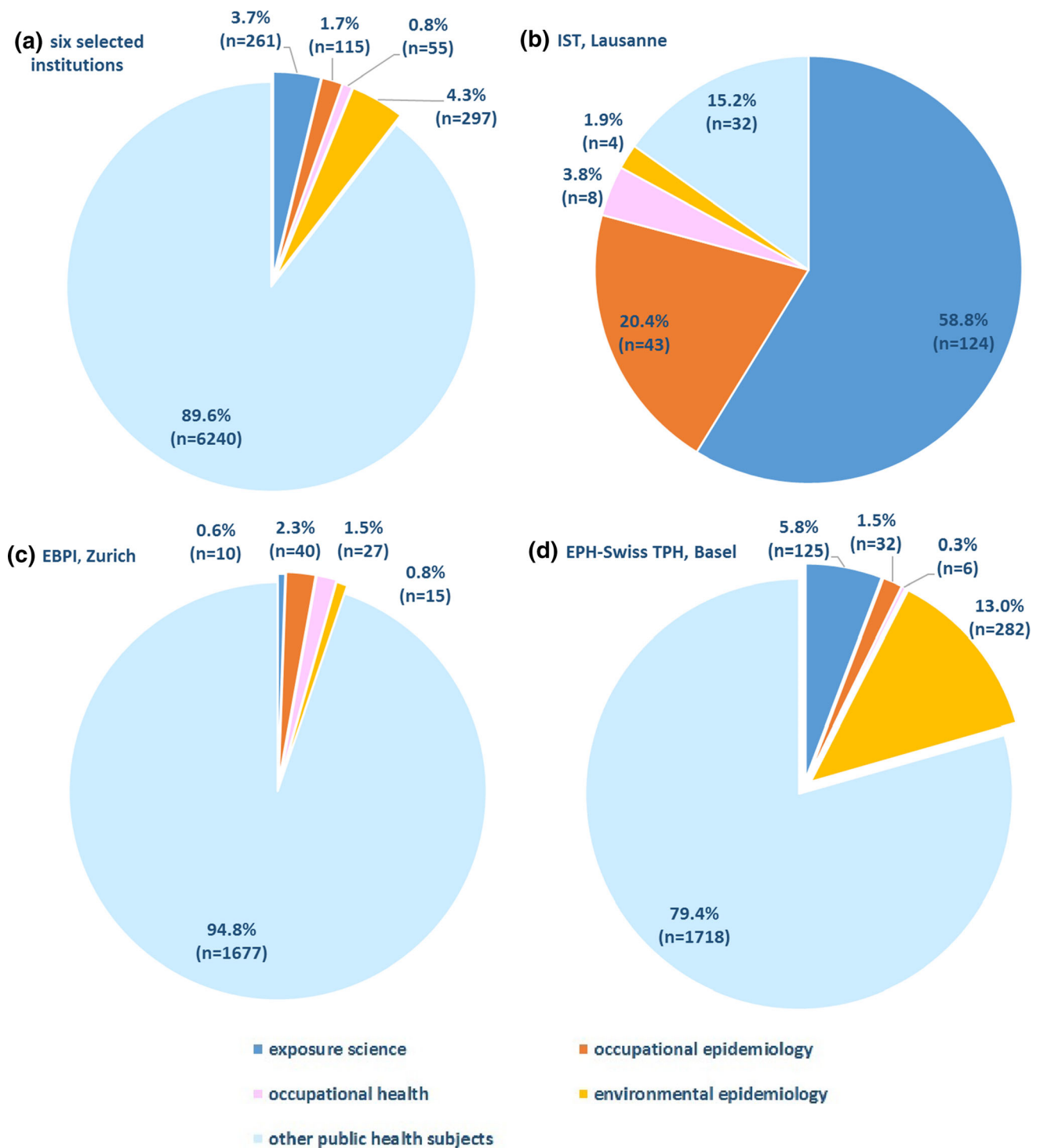


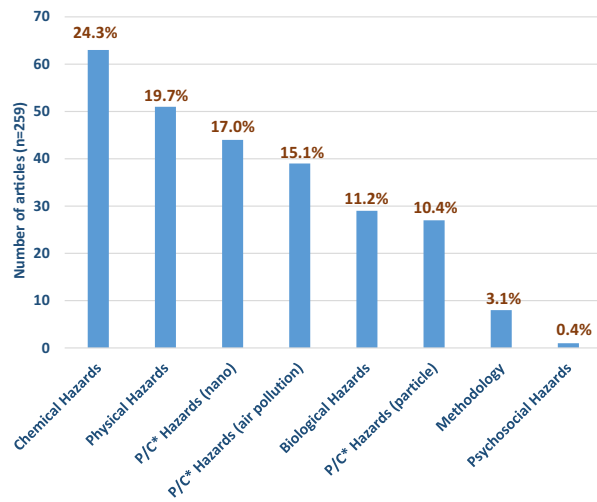
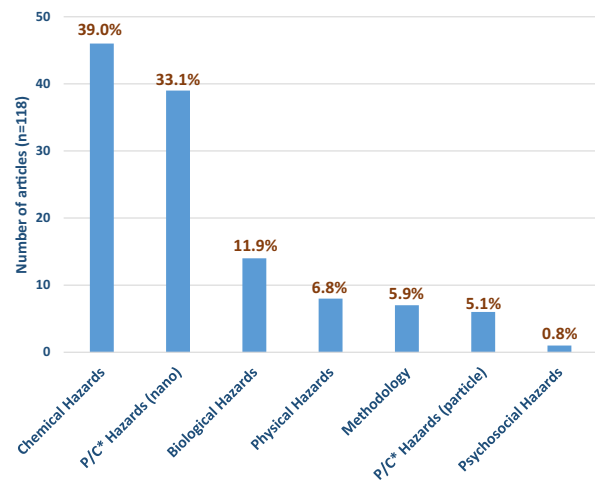
Fig. 2 Proportion of publications in occupational health and related disciplines in the six selected Swiss public health institutions and in the three institutions where this proportion is $\geq 5\%$, 2008–2017

Espace Mittelland has one per 86,500; Ticino has none (Fig. 4, Table 1).

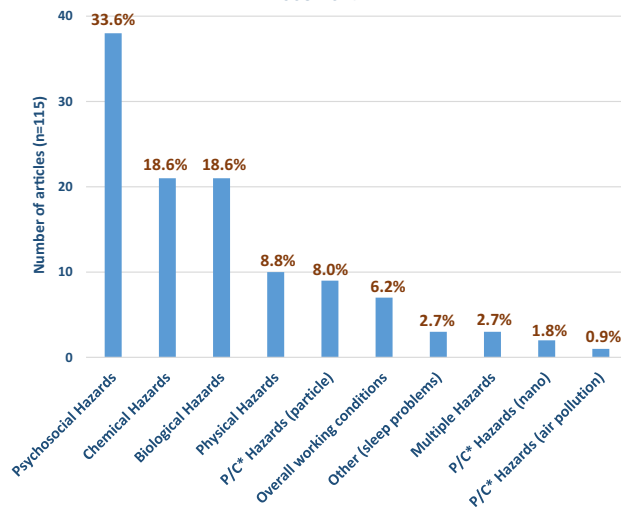
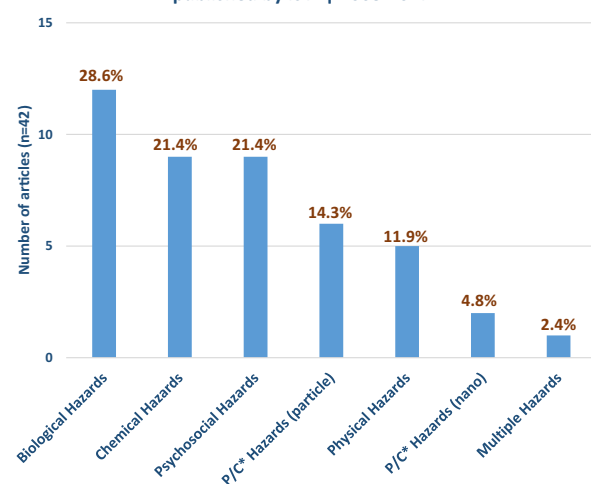
The number of people practicing ergonomics was 144 in 2017. A large majority (80%) has a university or higher education degree; 38% are in possession of a master degree

in ergonomics and 5% have a Master or a Diploma of Advanced Studies (MAS or DAS) in OH (SwissErgo 2017). In contrast with the situation for OHPs and occupational hygienists, while geographical variations exist, repartition is more balanced (Fig. 4, Table 1).

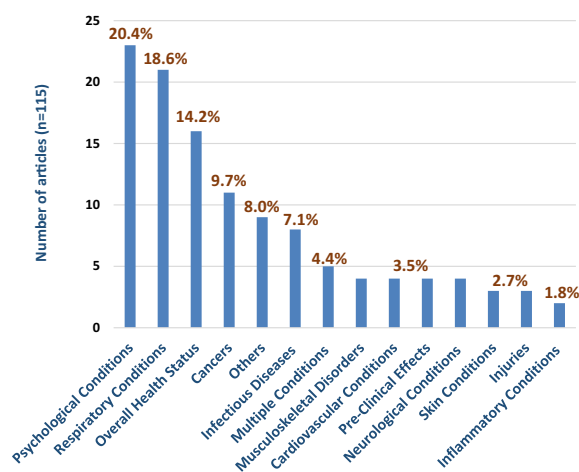
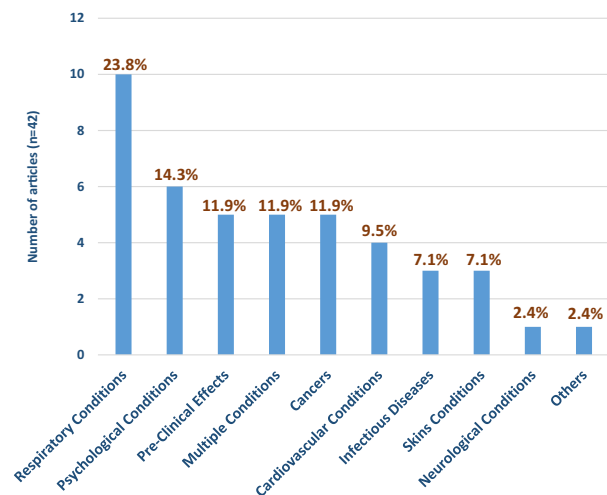
Hazards studied in exposure science articles | 2008-2017

Hazards studied in exposure science articles published by IST¹ | 2008-2017

Hazards studied in occupational epidemiology articles | 2008-2017

Hazards studied in occupational epidemiology articles published by IST¹ | 2008-2017

Health conditions or effects studied in occupational epidemiology articles | 2008-2017

Health conditions or effects studied in occupational epidemiology articles published by IST¹ | 2008-2017

◀**Fig. 3** Hazards and health conditions/effects studied in exposure science and occupational health epidemiology publications by the six selected Swiss public health institutions (including Institute for Work and Health (IST)) (left column) and by the IST (right column), 2008–2017

Discussion

Do hazards and health effects studied mirror trends in working conditions?

The results of our bibliographic analysis show that OH research has kept abreast of how working lives have

evolved: the proportion of articles related to psychosocial hazards and effects on mental health is a sign that in Switzerland as in other countries this theme is of strategic importance. Similarly, the share of publications on nano-materials, particularly in exposure science, indicates that Switzerland is building up an important and valuable knowledge in this specialized field. While the number and proportion of occupational epidemiology papers on cancers are not negligible, in a context where some studies have concluded on an underestimation of the number of cancers attributable to occupational causes (Boillat et al. 1997; Guillemin 2018), this problematic may need further investigation.

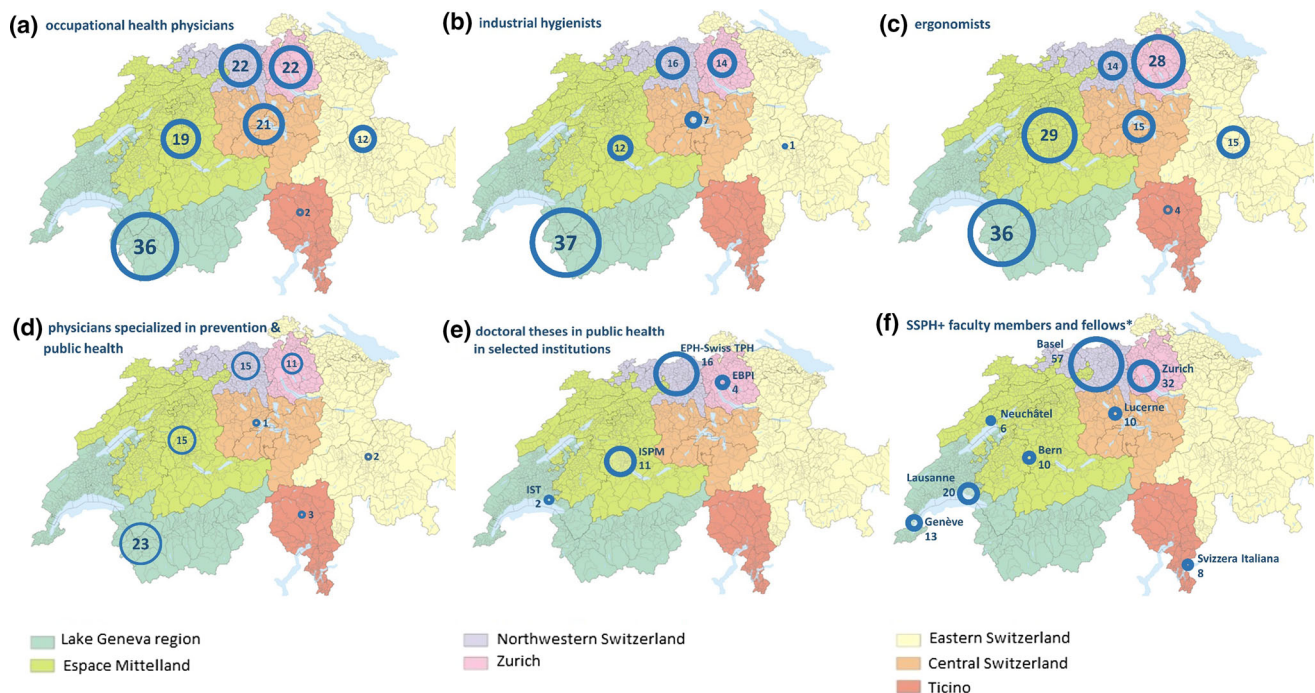


Fig. 4 Critical mass of professionals for practice of and research in occupational health in Switzerland in 2017

Table 1 Density of selected occupational health professionals in seven Swiss regions in 2017

	Density of occupational physicians ^a	Density of industrial hygienists	Density of ergonomists
Lake Geneva region	22,222	21,622	22,222
Espace Mittelland	54,632	86,500	35,793
Northwestern Switzerland	28,818	39,625	45,286
Zurich	38,955	61,214	30,607
Eastern Switzerland	55,583	667,000	44,467
Central Switzerland	22,190	66,571	31,067
Ticino	87,000	n/a ^b	43,500
National average	34,597	53,287	32,887

^aNumber of employed persons per capita of occupational health professionals. For example, in Zurich there is one occupational physician for 38,955 workers

^bNo registered hygienist identified in Ticino

What explanations for regional differences in OH research?

The disparities in the proportion of OH and related disciplines publications in the selected institutions seem to be the result of an historical and cultural evolution, which took a decisive turn in the early 1990s (Ramaciotti 2013). At the time, the OH departments of the Geneva and Lausanne Institutes of social and preventive medicine merged to create the IST. This evolution may explain the small proportion of OH publications in these institutions in their current denomination (IUMSP and IGH). Both the Zurich University and the Zurich Science and Technology Institute (ETHZ) have played an important role in establishing the fields of public health and OH in Switzerland: in 1963, Zurich University created the first institute of Public Health, which became the Institute of Social and Preventive Medicine (Zurich ISPM) while in the 1990s the ETHZ alongside the IST developed a MAS in Work and Health to train OH postgraduate specialists. In 2013, the Zurich ISPM and the OH department of the ETHZ merged to form the EBPI. In contrast, the ISPM in Bern does not seem to have ever played a significant role in OH, an orientation that holds true to this day.

Moreover, regional differences in the number of OH practitioners and research professionals are likely to reflect the local needs of the economy and authorities such as the density of medium and large companies capable of monitoring their workforce health status, regional differences in economic activities (e.g. chemical industry in Basel), and the sensitivity of local authorities to OH.

In the absence of a federal-level OH structure responsible for developing and steering an integrated research strategy, cantonal entities exert an important influence on the implementation of OH-specific health policies and programs. Research on this topic has shown that although numerous OH stakeholders work efficiently within their specified mandate, collaboration is limited, especially when it comes to OH data collection and sharing between federal, cantonal, and local levels (Graczyk et al. 2018). Overall, these regional disparities and the lack of research strategy and coordination at national level are likely responsible for the somewhat limited output of OH research in Switzerland and the absence of a more robust OH federal policy.

Are the results in line with international data available and overall trends?

Gehanno et al. (2018) analysed the trends in the number of articles and topics studied in OH publications from 1995 to 2015 and found that the annual growth rate of publications

was 1.8% during the first decade and 1.7% during the second. The type of diseases studied changed over time: respiratory diseases were the most frequently studied until 1991; thereafter, psychiatric and psychological diseases took the lead. Respiratory diseases ranked second with cancers a close third during the last 10 years. The proportion of articles on nervous system diseases increased steadily during the whole period. Our results are in line with these trends bar two differences: nervous system diseases are little studied in Switzerland where occupational epidemiology papers mostly focus on respiratory and psychological conditions with cancers lagging significantly behind (Fig. 3). While cancer epidemiology is flourishing in Switzerland, thanks notably to the availability of high-quality population-based cancer registries (Lorez et al. 2017), occupational cancer epidemiology is almost inexistent. The most likely explanation is that the variable occupation is rarely included in existing cohorts and databases.

Regarding temporal trends in environmental and occupational epidemiology publications, after 2009, the number of environmental epidemiology articles is consistently superior (Fig. 1); over the entire period, their number is almost three times that of occupational epidemiology (297 vs. 115). This picture seems consistent with the evolution of the Ecological Public Health Paradigm from the human-centred approaches towards the ecological model (Coutts et al. 2014; Lang and Rayner 2012). This evolution gave rise to the concept of exposome (Wild 2005) and led to massive investments in environmental and molecular epidemiology research. Interestingly, the curve of exposure sciences publications is almost parallel to that of overall public health publications; this increase in both might translate the adherence of Swiss researchers to the novel paradigm. Notwithstanding this progress, occupational epidemiology and OH research seem to have lost their overall visibility in this paradigm. Consequently, many scientific journals historically focused on OH added environmental health in their title and scope. According to Jennings (2016), the ecological model of public health has the potential to bring environmental health and OH into closer alignment, but at the moment our results contradict this.

Regarding the number of OH professionals, the literature available precludes comparison by OH speciality as most data concern only OHPs. The last ICOH survey reported substantial differences in the density of OHPs between countries (Rantanen et al. 2017). Finland and Italy had the highest densities, respectively, one OHP per 1234 employees and 2478 employees; the lowest densities were reported in developing countries (Rantanen et al. 2017). It is interesting to note that according to Gehanno et al. (2018), the countries that have a high level of publications

on occupational diseases were Finland, Sweden, and Denmark, followed by Italy, the Netherlands, and Canada. It would be worth investigating how strongly the density of OH specialists is associated with OH research output.

Strengths and limitations

For the publications analysis, we limited ourselves to six core institutions thus potentially missing some OH publications. The selected institutions employ a number of staff with strong statistics skills who may participate in studies outside of the strict public health domain; this may contribute to a lower estimate of the proportion of OH articles. Using institutional online repositories to quantify the number of Ph.D. theses and publications might have resulted in incomplete inventory even though we cross-checked the institutional databases with additional sources (i.e. website information, institutions' librarians). For some OH professionals, individual data were verified using publicly available information on their institution website or LinkedIn profile.

Regarding the number of OH professionals, we could not find reliable historical data for all categories. The best statistics were available for OHPs and PPHPs, as the FMH provides annual data on these specialties. For occupational hygienists and ergonomists, we were unable to obtain information on annual progression. The worst case was that of occupational epidemiologists, a speciality almost unknown in Switzerland. Indeed, while epidemiology is included in public health curriculum and training opportunities in clinical epidemiology are available at both master and Ph.D. levels, access to postgraduate training in other epidemiology specialties has been challenging. This situation prevented us from assessing accurately the number and evolution of these OH research professionals although they constitute a core resource in a multidisciplinary OH research team.

Notwithstanding these limitations, the number of OHPs and PPHPs enabled us to approximate this resource, even though there is no official information about activity level or engagement in research. However, we have some indications that time devoted to research activity is limited and varies depending on speciality and seniority. According to a survey conducted at the IST in 2017 (Guseva Canu, personal communication), the estimated median research full-time equivalent (FTE) is 12 (27.5 days/year) among 15 OHPs and 71 FTE (159 days/year) among 19 other OH professionals. The highest rate among OHPs was 23 FTE (51.5 days/year) and 100 FTE among others, and the lowest was 0 and 22 FTE, respectively. The survey revealed that both medical and other OH professionals wished to spend more time on research, with 8 FTE

(17 days/year) in average, but were too busy with their professional practice duties.

Similarly, the 2017 SwissErgo survey reported that 21% of ergonomists declared being engaged in research, but there was no indication on how much time they devoted to these activities. The number of OH professionals can thus constitute a rough indicator of resources available for OH research.

Another relevant indicator that would be helpful to assess the situation of OH versus public health research would be the number of research grants and the amount of funding allocated to the research in each domain and its evolution over the studied period. Assessment of these two indicators is challenging because of the absence of OH as a research domain or discipline within the Swiss National Science Foundation (SNSF) classification but would be worth investigating further.

Despite these limits, our study is the first to assess the state of Swiss OH research and to evaluate its temporal and regional trends. Based on comparison of our results with overall trends and international data available, we could assess their external validity. Based on the stratified analysis of changes in OH research topics (i.e. health conditions and risks) in line with socio-demographic changes in Switzerland and public health priorities, we could also check the internal coherence of our results.

Conclusion

Considering the high proportion of active workers in the national population and the profound changes in working conditions during the past 15 years, OH research seems to occupy a limited place in the Swiss public health academic landscape. Given the importance of OH research towards establishing evidence-based prevention and health promotion programmes, there is a need for this topic to be granted increased research attention in Switzerland. The development of a national and coordinated research effort in OH will require improved collaboration between regional and federal authorities as well as better communication and coordination between public health authorities and OH executive institutions (e.g. inspectorates) belonging to the economic sector.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Informed consent This research does not involve human participants and/or animals; consequently, no informed consent was necessary.

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