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Original Article

Making the Difference in Occupational Health: Three Original and Significant Cases Presented at ICOH Congresses in the 20th Century

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ABSTRACT

Background: The aim of this study is to illustrate the historical role of the International Commission on Occupational Health (ICOH) congresses as an arena where national and international occupational medicine can dialogue and as the first example of scientific transferability of the research and prevention results that have had such an impact on global public health.
Methods: We used the ICOH Heritage Repository, in which ICOH congress proceedings (from the first congress in Milan in 1906 to the last congress, held in Dublin in 2018), are organised in an orderly way, updated and easily accessible according to open access logic.
Results: We describe studies by three physicians who submitted significant scientific work to ICOH congresses, one on the battle against ancylostomiasis (Volante, 1906), the second (Quarelli, 1928) on carbon disulphide poisoning, and the third (Viola, 1969) on the carcinogenicity of vinyl chloride monomer. Priority is given to Italian cases, on account of the authors' obvious familiarity with the issues.
Conclusion: The visibility offered in ICOH conferences and their published proceedings has boosted the international spread of their findings, contributing to the scientific transferability of the research results and influencing the development of policies and prevention interventions that have had a great impact on global public health.

1. Introduction

In the last few decades, historiography has increasingly turned to historical sources in the field of occupational safety and health (OSH). The scientific community now needs to identify and systematize the relationships between data on the protection of health and safety of workers from different archives and to formulate an overall reconstruction of the historical patterns of experience, organizational models, and results, from the beginning of the 20th century until today.

In response to stimuli from international institutions, in Italy too the need has arisen to reconstruct the historical roots of occupational medicine, by retrieving sources, developing methods for interdisciplinary historical research, and identifying criteria for the transfer and use of results.

The first steps toward the formal recognition of the historical dimension of occupational medicine date back to the second half of the 1990s and various initiatives have been taken by the scientific community and by some institutions for the historiographic reconstruction of prevention and safety in the workplace [1]. Although there are reports of retrieval of archives and historical sources for the study of occupational medicine—in some cases also available in digital form—there is still no effective systemic work for retrieving and sharing the wealth of knowledge about the historical evolution of health and safety at work.

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Table 1
ICOH heritage repository

HOME > brief summary of the history and the organisation of ICOH.
ICOH HISTORY > History of ICOH through the fundamental moments that have led to the current structure of the organization.
CONFERENCES > hypertext list of Congresses classified according to:
year;
venue;
title;
dates.
SEARCH > search mask to filter the results through the search for:
names of the authors;
words in the title;
words in the text;
year or period.

To start with, the historical sources of occupational medicine can be explored, creating new forms of support and sharing the results (web platforms) for transferability and use, implementing potential statistical survey systems to give professionals a tool for dealing with risk prevention in the workplace. Information and communication technologies (ICT) have radically transformed the way we share and use knowledge, overcoming the difficulties of access to information, which in the past traveled mainly through transmission channels with structural limits for diffusion.

The aim of this study is to illustrate the historical role of international Congresses organized by the International Commission on Occupational Health (ICOH), the oldest international scientific society in the field of occupational health (founded in 1906), recognized by the United Nations and in a close working relationship with the International Labor Organization (ILO) and World Health Organization (WHO), as an arena where national and international occupational medicine is open to dialogue and as the first example of scientific transferability of research and prevention findings that have had such an impact on global public health.

2. Materials and methods

We present here the work of three physicians who submitted significant scientific papers at ICOH Congresses and contributed to the development of policies and prevention interventions in OSH. One (Volante) dealt with the battle against ancylostomiasis, the second (Quarelli) tackled carbon disulphide poisoning, and the third (Viola) described the carcinogenicity of vinyl chloride monomer. These three cases cover a broad period. In 1906, Giuseppe Volante participated in the first Congress that opened the way to the congressional history of ICOH [2]. Gustavo Quarelli was a speaker at the 5th ICOH International Congress in 1928 in Budapest, which was an important milestone for the resumption of these Conferences after the First World War [3]. Much later, in 1969, Pier Luigi Viola presented his study in Tokyo at the 16th ICOH International Congress (last year's was the 50th anniversary) [4]. Priority was given to Italian cases, on account of the authors' obvious familiarity with the issues addressed.

These three articles can be found in the ICOH Heritage Repository, in which ICOH Congress proceedings are organized in an orderly way, updated, and easily accessible according to open access logic (http://repository.icohweb.org/). To date, all volumes of the proceedings of the 32 ICOH Congresses (from the first Congress in Milan, 1906 to the last Congress, held in Dublin in 2018) have been digitized (Table 1). With over 50,000 authors listed who submitted studies on occupational health at ICOH international Congresses, this is the most complete collection of scientific publications in occupational medicine today.

It is of course understood that the ICOH Heritage Repository allows a historiographic analysis of the cases that are not discussed in our study. In the case of Quarelli, there is another abstract in the Repository, presented in 1931, which concerned pneumoconiosis [5]. Viola had presented three other abstracts at ICOH Congresses: research on cyclohexane metabolism (1960), mercurial poisoning in the electrolytic metabolism of sodium (1963), and cyclohexane metabolism (1966) [6–8].

We took into consideration all Congresses, according to the series and the official numbering; therefore, Conferences or Congresses on particular issues or somehow outside the official series are not included, even those promoted by ICOH.

For our searches, we crossed three search keys (author's name, title of the publication, and keywords, to which we added the Congress year and the language in the advanced search). The whole proceedings of the international Congresses total more than 20,000 and are downloadable in Acrobat Reader format.

3. Results

3.1. Anticipating the primary health care approach in the construction of the Simplon tunnel—GIUSEPPE VOLANTE (Milan 1906)

The list of Congresses in the Repository opens with the **First International Congress on Occupational Diseases** held in Milan from 9 to 14 June **1906** in the framework of the International Exhibition [9]. This was the first international debate on issues relating specifically to occupational medicine, in particular to the great industrial, human, and medical effort required for the construction of the Simplon tunnel, inaugurated on that occasion.

In his inaugural address at the Congress, Malachia De Cristoforis (1832–1915), an Italian physician and politician, remembered the victims among workers building the tunnel and emphasized the importance of acting not just after accidents, which are the most striking and tragic events, but also on the pathological aspects of working conditions and occupational diseases: “We are happy and proud of our Simplon tunnel! But it is not enough to remember the fallen in a rapid lightning stroke: to absolve ourselves we must reflect on the damp-saturated environment without direct light, with very high temperatures, in which hundreds of men worked endlessly long hours, until the heart beat 160 times per minute and the heat of their poor bodies touched fever point!”[10]. Even though the Simplon tunnel marked a prodigious victory in the technical field of tunnel construction, there is a striking scarcity of Congress reports concerning the health organization of tunnel sites.

The exception is the scientific contribution entitled *Health and hygiene conditions of the Simplon works* by **Giuseppe Volante (1870–1936),** which was published in the Congress proceedings, even though it was not actually presented during the scientific session [2,11]. In view of the broad debate and the timing of oral communications, not adapted to the number and scientific level of the contributions, Volante was not considered among the most senior authors and was not assigned priority in the discussion.

Volante's work came at a critical moment for occupational and environmental prevention. At the beginning of the 20th century, the history of OSH went through one of its highest periods, and Italy made significant contributions in Europe and internationally. These were years of affirmation and institutionalization of occupational health, where people became more sensitive to prevention for workers, following recognition of the “humanitarian disasters” due to poor working conditions [12,13].

The contribution is available in the Repository and illustrates the intense activity of prevention put into practice on site, as Volante explained: “The Simplon tunnel has marked a prodigious victory in

the technical field of tunnel construction, for the enormous difficulties overcome, and has also been and will be the leader in the more human field of worker health and life protection."

The considerable length of the Simplon tunnel made it hard to solve the problems of ventilation during excavation and its great depth meant it was even harder to keep the temperature compatible with the workers' hygiene, enabling them to work productively. The heat and humidity facilitated fermentation of body excreta, which remained on the ground in the tunnel, some containing the larvae of intestinal parasites.

"We hygienists greatly welcome the excellent results obtained in this regard, with the simple and scrupulous application of hygiene dictates"[2], commented Volante. A pupil of Edoardo Perroncito (1847–1936), he was a parasitologist to whom we owe the discovery of ancylostomiasis or miners' anemia. He was much appreciated by the scientific community for his "foresight, his constant thought on the rational and scientific application of hygiene postulates"[14] and at the First International Congress on Occupational Diseases (1906), which was the first international meeting on occupational health, there were many who praised him with words of esteem.

Perroncito himself expressed admiration for Volante during the presentation of his contribution *Occupational diseases of a parasitic nature*: "Modest but smart, Dr Giuseppe Volante knew how to implement measures to prevent the development of cases of anemia from parasite infections (protozoa, roundworm, hookworms, eelworms, whipworms, etc.) based on modern knowledge"[15].

Volante was also defined by Luigi Devoto (1864–1936), founder of the Milan Clinica del Lavoro, "modest and simple"[16], a man capable of showing emotion in response to the applause of colleagues from around the world.

These repeated testimonies of esteem, accompanied by emphasis on Volante's modesty and his tendency to adopt practical measures to prevent and combat diseases, testify to an attitude of the luminaries of occupational medicine of the time, who saw Volante as a physician actively engaged in adopting preventive and organizational measures as well as in the study of medicine.

This is a consideration that seemed a bit limiting at that time, but which today appears referable to a very interesting current aspect of the activities of Giuseppe Volante. As medical director of the Iselle site, on the south side of the Simplon tunnel—the Italian part of the works—Volante had the merit of adopting specific hygiene/health measures that prevented the spread of hookworm disease (ancylostomiasis or miners' anemia) during the construction. This contrasts with what happened during the construction of the Gotthard tunnel (1872–1882) when a hookworm disease epidemic caused hundreds of deaths [15]. Volante systematically documented the health innovations implemented on-site in a series of articles: *The provinces of Italy at the Simplon tunnel*, *The most humane of victories,* and *The family of the miner at Simplon.* Subsequently, these articles were collected in the book *The health and hygiene conditions at the Simplon works* [17] with a preface by Vito Foà. The monograph includes a section by Gaia Piccarolo *The worker's home at the Simplon tunnel* and an interesting photographic presentation that testifies how Volante organized the Simplon site.

One of the most important hygiene measures was "bathrooms" for the workers located just at the entrance of the tunnel, which workers could access through an artificial wood tunnel without exposing themselves, with a sweaty body and water-soaked clothes, to the cold external environment. These bathroom areas comprised many rooms with hot showers, tubs, and sinks, where workers leaving the tunnel could wash themselves and change their clothes immediately. Also available was a system of pulleys to hoist wet clothes up to the top of the room, where a current of hot air dried them [18].

Feeling deeply responsible for the health of the site workers, Volante began a targeted sociological survey [19], as Baldasseroni and Carnevale, historians of occupational health, defined it. Other health measures were hygiene concepts and rules for the miner (e.g., use of footwear), sufficient drinking water for workers, 'portable' latrines in the workplace, and penalties for workers who did not comply with the rules.

To these hygiene/health measures, close health surveillance was added: "Before being admitted to work, every worker was carefully visited by the physician with the aim of making sure of his physical aptitude, the state of his health and especially to prevent any individuals suffering from hookworm disease entering the tunnels. Great care was also taken to spread among the workers sound principles and rules on hygiene, through conferences, billboards and pamphlets, and warning them against the dangers threatening the integrity of their health"[2].

Among Volante's initiatives, the study of the socio-cultural conditions of the miner's family setting is important, demonstrating a vision which, starting from the problems of hygiene, focuses on concern to guarantee the worker and his family suitable living conditions. Volante proposed innovative solutions: schools to combat illiteracy; the construction of accommodation at Balmalonesca (a village near Iselle, which housed 8,000 people during the tunnel construction); and attention to wellbeing on the site.

In consideration of the "fewer victims" [17], the coordinated, capillary hygiene action that made the Simplon an example on a European and international level was presented as "the most humane of victories" [14]. On the whole, 63 deaths from disease were recorded, 20 due to injury (far fewer than in previous experience—Gotthard *in primis*), and 3,850 injured workers were reported to the Italian Cassa Nazionale.

Volante paid attention not only to workers' health but also to the community as a whole, through the adoption of preventive and organizational measures as close as possible to the living and work places. This makes him the predecessor of the *Primary Health Care* [20] approach, adopted in the Declaration of Alma Ata in 1978, which then became a central concept in WHO's objective of health for all [21].

3.2. The discovery of the effects of carbon disulphide in the artificial silk industry—GUSTAVO QUARELLI (Budapest 1928)

This review of case studies continues with the **5th ICOH International Congress**, held in Budapest from 2 to 8 September **1928**, which marks an important stage in the resumption of scientific output in the field of health and safety in the workplace, after a break due to the First World War.

Among the noteworthy reports presented at the Congress in Budapest, both for the Italian work context and for the study of occupational diseases, there was *Carbon disulphide poisoning in the processing of artificial silk* by **Gustavo Quarelli (1881–1954)** [3]. In 1915, Luigi Devoto, in a report on the activities of the Milan Clinica del Lavoro, had already warned that "poisoning by carbon disulphide, which in the past was frequent in rubber factories, is no longer observed; but it is [seen] in the factories of artificial silk" [22]. Quarelli, an occupational physician and scholar, had for more than a decade clinically described hundreds of cases of poisoning by carbon disulphide among the employees involved in the production of artificial silk (viscose).

The monograph by Paul David Blanc [23] on the history of the systematic poisoning of workers in the synthetic fibers industry, from the middle of the 19th century to today, depicts the sad reality of thousands of people who were poisoned at work because of the

economic and political interests pressing for the use of this substance and the inability of the inspectors to acknowledge warnings by several researchers on the toxicity of carbon disulphide for the worker. *Fake Silk* is also a tribute to all those physicians and researchers, including Quarelli, who described the tests for this toxicity and contributed to establishing limits and standards for protection.

In the 1920s, the United States and European countries tended to evade this question from the scientific, political, economic, and social points of view: physicians ignored the problem and factory owners (who were well aware of it) hid it so as to prevent their profits falling [24].

Between 1926 and 1935, Italy had in the meantime become the second largest producer of synthetic fiber in the world after the United States, thanks to the initiative of a few industrialists, such as Riccardo Gualino (1879–1964), who generously supported the Institute of Occupational Medicine in the Medical Faculty of Turin, where Quarelli held the post of professor in the occupational diseases clinic in 1929.

The Italian artificial silk industry employed about 20,000 workers in 27 companies. One of the largest factories in Italy, founded by Riccardo Gualino, was SNIA Viscosa [25] with 2,500 workers. SNIA artificial silk production processes were similar to those used in other Italian factories. The factory felt the effects of the principles and the social and cultural rhetoric of fascism, through an advertising campaign [26] in favor of this production. Over time, the psychophysical conditions of workers in the factory suffered from increases in the pace of work, the lack of health care, and the use of carbon disulphide in the processing [27].

In his scientific contribution presented at the 5th ICOH International Congress (1928), Quarelli explained how carbon disulphide poisoning is possible even if at a first diagnosis, when it may not show up in an acute form, it is mistaken for a simple form of neurasthenia. The disease manifested itself with loss of muscle strength and sexual potency, with hypo-excitability of the nerves and muscles and—in almost 30% of cases—with signs of extrapyramidal distress (known as the Quarelli syndrome) [3]. In 1929, Quarelli described cases with Parkinson-like manifestations—muscle rigidity, amimia, and characteristic tremor—in artificial silk workers exposed to carbon disulphide [28,29].

Poisoning by carbon disulphide in the processing of artificial silk acquired important, social significance due to the increase in epidemiological data of those years: workers sick with acute psychosis were put away in insane asylums and escaped observation by occupational physicians. Later, the real number of sick workers was distorted by the extremely high turnover (up to 120% for females and 90% for males over five years), which meant that the weakest abandoned factories quickly [30].

In 1934, Quarelli made known a summary of his research that described two first cases of narcoleptic crisis in those poisoned by carbon disulphide, with striatal syndrome [31]. On an international level, in 1925 Alice Hamilton (1869–1970), an American expert in the field of occupational medicine and pioneer in industrial toxicology, published the book entitled *Industrial poisons in the United States* [32]. She reported research on the toxicity of carbon disulphide in other countries too, demonstrating that if European studies had been taken into consideration, probably the United States would have saved several years of research and acknowledgment on the subject.

In the 1930s in the United States, Hamilton launched a field survey to study the risks of carbon disulphide in depth. Her findings were the same as in other European countries: madness and mental disorders, suicide attempts, eye and skin problems, etc.

Aristide Ranelletti (1873–1945), a lecturer on occupational medicine in Rome, reported that the results of Quarelli's studies and of his Italian colleagues on carbon disulphide poisoning served as a basis for technical and hygienic improvements to some artificial silk processes, making cases of poisoning increasingly rare [33]. The 1940s followed with studies by Enrico Carlo Vigliani (1907–1992) in Italy [34], Alice Hamilton in the United States, and other foreign authors, who reported that chronic carbon disulphide poisoning caused diffuse arteriosclerotic encephalopathy with very different signs and symptoms from case to case.

Vigliani focused on carbon disulphide poisoning in Italy. He treated 100 cases between 1941 and 1942. In Milan, he observed more cases with a longer follow-up and noted that the disease was starting to change: in a publication of 1955, he linked carbon disulphide with arteriosclerosis [35]. Vigliani continued his studies of the pathogenesis of encephalopathy with the contribution of the Milan psychiatrist Carlo Lorenzo Cazzullo (1915–2010).

Quarelli made a great contribution to occupational medicine as a discipline with the publication of his manual *The clinic of occupational diseases* in 1931, intended as a manual of occupational medicine. In the preface to the work, we read: “In the new hygiene rules, the factory doctor is given particular legal status as a real health officer of the company, invested with authority and responsibility, *inter alia* punishable with a fine, tenfold compared to free medical practitioners, in case of failure to report an occupational disease. Even for this category of colleagues, I therefore find this practical, concise but complete manual particularly useful and appropriate for an orientation to certain diagnosis” [36]. The clinical symptoms of carbon disulphide poisoning are laid out in detail in his treatise, but also of all the occupational diseases known until then, such as for example benzene, lead, mercury, chromium poisoning, and the range of pathologies related to physical and intellectual fatigue.

In Italy, growing industrialization brought up the question of the protection of workers from occupational diseases, also through the nascent trade unions, which impelled the legislator to start adopting the appropriate measures, first with specific legislation, then with the establishment of a labor inspectorate, which also had a medical component. With the Royal Decree no. 928 of 13 May 1929, which came into force on 1 January 1934, workers' protection was extended to those insured against accidents at work, and even occupational diseases in industry [37]. Carbon disulphide poisoning was one of the first occupational diseases recognized. Shortly afterwards the Royal Decree no.1765 of 17 August 1935 was adopted [38]. It reported not only the nomenclature of the diseases but also the disease symptoms (anemia and paralysis from carbon disulphide, psychosis, and neuritis).

3.3. The discovery of carcinogenicity of vinyl chloride monomer in the plastic industry—PIER LUIGI VIOLA (Tokyo 1969)

The review of the case studies concludes with the **16th ICOH International Congress**, from 22 to 27 September **1969** in Tokyo. The Congress had a substantial international impact and boasted 343 presentations and communications in three scientific sessions. One of these scientific communications came from **Pier Luigi Viola (1917–1985),** a name unequivocally linked to the discovery of the toxic effects, in particular carcinogenic, of vinyl chloride monomer, a substance that entered industrial practice in the 1960s for the production of plastics such as polyvinyl chloride (PVC). The diversified and not systemic descriptions of some harmful effects of vinyl chloride monomer in articles published in the 1940s and 1950s did not yet permit precise recognition of this new “occupational disease.”

On the basis of his own experience as an occupational physician at the Solvay plant in Rosignano (Tuscany Region), and an analysis of the literature, Viola came upon the description of a “disease from

vinyl chloride." This started from studies of cases of acroosteolysis (destructive alterations of the distal phalanges of the hands) in manual tank cleaners in PVC production in a Solvay factory in Belgium in 1963. However, at first the specific cause remained uncertain [39]. As a result, Viola attempted to set up an animal model for acroosteolysis, in which rats were exposed to vinyl chloride.

The toxic effects on these chronically intoxicated rats were described in a paper presented at the 1969 Tokyo Congress of Occupational Medicine. This stated that 'chronic exposure to vinyl chloride vapor can determine in man a syndrome characterized by alterations of the skeleton, the teguments, nervous system, and hepatic functions' [4]. However, his paper did not mention any carcinogenic effects in these animals.

Only in 1970, at the International Conference on Cancer in Houston, Viola referred to the carcinogenicity of vinyl chloride monomer. He argued that judging from experimental data, "vinyl chloride is an effective carcinogenic agent for the rat." However, he then added that no implications to human pathology could be extrapolated from the experimental model [40]. In May 1971, Viola published his findings in the journal *Cancer Research* [41] and was invited to Washington by the Manufacturing Chemists Association (MCA) to present a summary of his work. The MCA, upset by his findings, began to develop a research protocol to assess the carcinogenicity of vinyl chloride. Subsequent studies confirmed the carcinogenicity even though the direct effect on man had still not been fully demonstrated [42].

For this reason, in 1972, the European industry gave Cesare Maltoni (1930–2001), Director of the Bologna Centre for Cancer Prevention and Oncological Research, the task of verifying Viola's discoveries. Maltoni had the opportunity and the funding to put into practice a new way of doing research in this field. He realized that one of the problems of the previous studies was the absence of reliable experimental models, producing conclusive evidence. Maltoni's data confirmed that exposure to vinyl chloride was the cause of cancer not only in animals but also in man [43–45], even at doses lower than those indicated by Viola.

This discovery, made known to the international community, was fundamental to the development of awareness on the subject and the adoption of new international regulations regarding the worldwide plastics industry. These led to revision of the whole production cycle with massive reductions in the concentrations of the compound in the working environment. Some examples are the adoption of Directive 78/610/EEC on the protection of the health of workers exposed to vinyl chloride monomer, transposed in Italy with Presidential Decree 962/1982, and the monographic studies by the International Agency for Research on Cancer (IARC) [46].

However, we owe Pier Luigi Viola the great merit of being the first to have studied and analyzed the phenomenon and of having brought it to the attention of the international community despite the difficulties in exposing it. At the health summit of physicians who worked in Solvay factories (2–4 November 1977), he said: "The scientist is obliged to increase his knowledge and to make the most exact photograph possible of the dangerousness of products. It is then up to others to support and promote those legislative measures that if on the one hand must protect that indispensable good that is the health of man, on the other hand must worry about not destroying the sources of his wealth. On this occasion, everyone must take responsibility, and turning back for fear of compromising oneself is not allowed."

In some unpublished notes in an article later published in the journal "La Medicina del Lavoro," Viola stated "To you who have responsibility for the health of many thousands of workers, I hope you continue to exercise your art with vocation, perseverance, and competence even if this may cause suffering […] the anguish of the researcher for whom the results of scientific investigation create ethical problems in respect of human health and for which he has to make decisions alone, based essentially on his own conscience"[47].

4. Discussion and conclusions

In recent years, numerous studies have highlighted the importance of using historical sources and archive material for the study of occupational medicine, because critical study of the health of workers and the historical evolution of safety at work make it possible to frame the historical and social phenomena in a wider perspective. Intense scientific activity in occupational health has led to the production of numerous contributions from leaders in the field of prevention. However, these have tended to be scattered among diverse journals or archives, with the result that this noteworthy and important output is nowadays fragmented and hard to find.

In this perspective, we find the work of research, collection, and arrangement of the documentation in the ICOH Repository, the most complete collection of scientific contributions in occupational medicine available today. It serves to provide not only greater understanding of how the history of international occupational medicine has evolved, but also how this contributes to legislation in individual countries, allowing a cross-check of the links between the different national approaches.

The Repository can shed light on the roles of the numerous occupational medicine scholars who have made original contributions to the national and international debate on health and safety in the workplace. By way of example, described here are the scientific contributions made by three occupational physicians at three ICOH international Congresses. These are scholars who participated in the development of occupational medicine with interventions that were innovative for their times. Volante introduced avant-garde hygiene and health procedures and anticipated the concept of "health surveillance" of workers. His attention not just to the health of the miners but also to the living conditions of the miner himself and his family (accommodation, schools to combat illiteracy, etc.) makes Volante a predecessor of the *Primary health care* approach. As an attentive observer, he also managed to introduce innovative and transdisciplinary aspects by participating in engineering work, preparing a first approach to epidemiological statistics and moving toward preventive, technical, and organizational measures. He facilitated and catalyzed different aspects of prevention and protection in occupational medicine, taking up the Ramazzini method.

Although Volante was appreciated by the scientific community, his professionalism was not sufficiently acknowledged in the literature. There is a serious lack of studies concerning the health organization of tunnel sites. The exception is Volante's scientific article entitled 'Health and hygiene conditions of the Simplon works'.

Quarelli was a pioneer in studies on carbon disulphide poisoning, looking into its effects among workers involved in the production of artificial silk (viscose) from the clinical and experimental viewpoints (Quarelli syndrome), and eventually achieved important national and international recognition. To date, research on the toxic effects of carbon disulphide has enabled the WHO to recommend the parameters and concentration limits of carbon disulphide in processing (1979 and 2000).

Nevertheless, according to the National Institute for Occupational Safety and Health (NIOSH), legislation is still not adequately protective regarding the use of carbon disulphide in the viscose industry and other processes in some countries such as China, India, and Indonesia. Today, as then, scientific studies on the subject

can help in the recognition and definition of toxic effects on man and the environment, illustrating the importance of this research.

Finally, while PVC production was in full swing, Viola had the merit of having found the first tests of the carcinogenic effects of vinyl chloride early, although with difficulty because of a conflict of interest with industry. He helped set in motion a process that in the space of ten years led to European legislation on the subject. However, Maltoni was considered the world-renowned leader in research on the hazards of industrial carcinogens in the workplace, who had the opportunity to put into practice a new way of doing research in this field.

In the decades that followed, interesting studies were reported, including a case series study on the mass intoxication of workers at an electronics factory in Korea due to 2-bromopropane (2BP; isopropyl bromide), which was the possible causative chemical of reproductive and hematopoietic toxicity [48,49].

These three scientists have in common the fact that they were able to combine their daily clinical commitment with research, which had a great impact on public health. Starting from the direct observation of workers' diseases, they continued their own studies guided mainly by intuition and their passion for research. In addition, in a period when it was difficult to move around and travel internationally, these three occupational physicians decided to present the findings at international scientific Congresses. The visibility offered by ICOH conferences and publication of the proceedings meant their studies could spread internationally, contributing to the knowledge of hookworm disease, carbon disulphide poisoning, and the carcinogenicity of vinyl chloride monomer. Their original contributions, presented for the first time at ICOH Congresses, laid the bases for subsequent research, also by other authors (Hamilton, Maltoni), and for the development of international standards to protect the health of workers.

Conflicts of interest

There are no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2020.03.004.

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