Bernardino Ramazzini’s *De Morbis Artificum Diatriba* on Workers’ Health—the Birth of a New Discipline

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**Abstract**: This paper provides a picture of the observations made over three hundred years ago by Bernardino Ramazzini (1633–1714) in light of current topical issues ranging from health problems related to work and lifestyle habits to the current burdensome COVID-19 pandemic. The main aspects of his work consist of descriptions of disorders linked to environmental risks, suggestions for measures for risk protection, and recommendations for healthy living. This paper focuses on Ramazzini’s most relevant achievements by (1) analyzing the episodes that stimulated the composition of his main work and highlighting some observations on which current epidemiological and toxicological studies are based; (2) reviewing his work showing not only the systematic descriptions of work-related illnesses caused by occupational factors but also his sound etiological and physiopathological contributions to the field of occupational lung diseases, breast cancer, and environmental disorders; and (3) remarking on his main observations in the fields of risk prevention and health promotion, also in the light of some highly topical issues related to unhealthy lifestyle habits and the COVID-19 pandemic.

**Keywords**: history of occupational medicine, occupational health, health promotion, lifestyle, COVID-19 pandemic.

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cal period in which he lived. Ramazzini was born in Carpi, a small village in the Padana Valley, Northern Italy. Today, Carpi is a thriving town with a reputation for technological innovation, but in the second half of the seventeenth century it was a small lowland village close to Modena, the capital of the Duchy of Este. The Duchy was one of the small states of the Italian peninsula under a strong foreign influence. The life of the citizens and the economy were conditioned by high taxes and tributes to support wars and a life of extreme luxury and blatant favoritism for the nobles and the ecclesiastical classes.

The economy of the territory was based on agriculture and animal husbandry, whereas the 20 thousand people of the cities were mostly engaged in the production of goods and services for the ducal court. The working and manufacturing techniques were mostly those of the Middle Ages and Renaissance, and significant innovations would begin only with the Industrial Revolution [4]. The development of the economy and technology was hampered by the introduction of several monopolies that controlled the production and trade of non-agricultural goods. The government of the time granted monopolies of tobacco, salt, and collection of rags for papermaking, and the right to be the sole owner of soap manufacturing, glass manufacturing, and saltpetre collection for gunpowder [5].

Most of all, freedom of thought and expression was opposed by the church and the presence of an ever-active Inquisition. In the same year in which Ramazzini was born, 1633, Galileo Galilei was dragged before the inquisitors in a trial that ended with his criminal conviction. Ramazzini himself complained of having been the object of attention from an ever-active Inquisition for having published a literary piece [6]. He had an unconventional attitude towards the powerful authorities, and did not hesitate to criticize some hygienic customs and the burial of corpses inside the churches.

That time was characterized by recurrent epidemics transmitted by belligerent armies. Plague epidemics in the second half of the 17th century and occasional typhus, smallpox and malaria epidemics beset significant segments of a severely malnourished population that lived in precarious hygienic conditions. Those conditions marked the beginning of a long period of famine, and the Italian peninsula prepared to face a deep economic recession. Ramazzini became a doctor and was appointed court physician and the first professor of the new university of Modena in that period characterized by poor health conditions, limited freedom, and oppressive cultural conditions. Despite his belonging to the more wealthy class, he did not hesitate to study a subject hitherto neglected, which attracted criticism from his colleagues [7]. Ramazzini carried out his studies in that historical context marked by famine, epidemics and wars, culminating in the publication in 1700 of the first edition of the Diatriba and in 1713 of a new and improved edition [8].

The origin and development of the idea to deal with workers’ health

Ramazzini was a brilliant clinician and a doctor attentive to poor people’s health, a curious scientist who investigated unusual realities and offered the medical world a book that addressed a new subject. He explored workshops, talked to people, studied their working conditions, and described the diseases that characterized many professions. Aware of the importance of a matter that did not seem to have been treated previously, he wrote “I believed that it would benefit the commonwealth of mankind if I should examine carefully the special diseases of workers and prescribe suitable remedies, a task that no one had undertaken hitherto” [8]. He clearly recognized that his work was imperfect, and his intention was to stimulate others to lend a helping hand to formulate a complete and thorough treatise worthy of a place in the field of medicine.

It is not easy to trace Ramazzini’s first interest in the issue, and it is not known when he made his first observations, but some details can be reported which help to clarify this aspect. The first was the study of some environmental factors and people’s diseases [9]. Second was observations made in the wells, reporting that workers were forced to stop the work due to the rising of too much steam that suffocated them [10]. Third, in 1690 Ramazzini held for the first time a monographic course on workers’ diseases in which he explained and commented on the experiences he had had in previous years [11].

While it is difficult to establish a precise dating of
Ramazzini’s interest in the matter, he clearly described when he began cultivating the idea of addressing workers’ health problems. Chapter xiv of Diatriba deals with the diseases of scavengers, cleaners of privies and cesspits («ut Foricariorum morbos, eorum scilicet, conciere possim»), and describes the episode that gave him the inspiration for his composition, stimulated his interest, and encouraged him to carry out the project that highlighted the terrible and demeaning working conditions [8] (Figure 1). The event occurred near a sewer for the disposal and purging of black water that took place on the days dedicated to rest during which work activities were suspended [12]. In that context, Ramazzini reminded his colleagues of Hippocrates and urged them to take care not just of the richest people’s health but also of unfortunate workers’ health by investigating their most awful working environments. He expressed some ironical doubts, however, about the real willingness of his elegant and immaculate colleagues, accustomed to the pleasant perfumes and fragrances of apothecary shops, to engage in such activity [13].

The protagonist of the episode was a scavenger who was engaged in the periodic purge. Having noticed the high speed with which the worker carried out the work and being intrigued, as well as moved to compassion, Ramazzini questioned him. This approach was a major contribution to medical practice: since then, all doctors have had to ask their patients information about their job [14, 15]. Ramazzini learned that the exhalations of putrid materials were responsible for serious eyes ailments but they did not cause any other health problem («neque pars ulla in hoc opere multatur praeter oculos»). The scavenger added that the disease in his eyes forced him to stop working after four hours («quatuor horis in hoc loco morari») and claimed that exercising such activity for a long period usually led to blindness (si opus istud alterius prosequi velim, propediem coecus fiam, ut alis contigiti). Ramazzini carefully examined the worker’s eyes and found that they were extremely bloodshot and weak (eosque non parum rubore suffusos ac obnubilatos observavi). Realizing that other workers of that class would exhibit the same symptoms, he investigated and discovered that many workers who had performed the same job had become semi-blind or completely blind and now begged for alms on the street (id genus vel luminumus, vel prorsus coecos per civitatem stipem emendicantes observavi). Hence, he hypothesized that the responsibility for the damage could be attributed to some volatile substance emitted from that environment full of filth (acidum volatile esse illus, quod, hujusmodi camarina commota, exspiret). In support of this hypothesis, Ramazzini argued that the same substance was responsible for the blackening of the copper coins carried by several scavengers in their bags (probabiliter ostendunt monetarum ex aere). As for any possible remedy, the scavenger said that the only cure was to run home (quam ut actutum, uti modo faciam, domo sua repetant) and spend a whole day in a dark room (in conclavi oscuro se recondant), occasionally washing his eyes with warm water to relieve the pain (oculos aqua tepida identidem abluendo). Unable to offer useful preventive measures, Ramazzini suggested that those workers fasten transparent bladders to their faces (ut vesciculas translucidas ori apponant) or stay at work for a shorter period (vel breviori mora in expurgandis cloacis se exerceant). He did not appear too convinced of the effectiveness of those remedies, however, so much so that he argued that if these measures failed, scavengers, cleaners of privies and cess-
pits, would have to give up that occupation and look for another job (artem hujusmodi deserant, & alteri se addicant).

Current relevance and soundness of Ramazzini’s observations

In addition to revealing Ramazzini’s humanitarian attitude shown by talking to a poor man [16, 17], the episode described above is relevant for several other reasons. First, he valued an important aspect of the working technique: the speed of execution aimed at limiting the exposure to noxious emissions.

Second, he ascertained eye damage caused by harmful materials in not just a single subject. He studied the problem further and found that all of those who performed that activity for a long time had gone blind.

Third, he speculated that exposure to the substance in a short and well-defined time could have caused the eye damage that led to blindness in a cause-and-effect relationship.

Fourth, Ramazzini correctly assumed that the material was responsible for the damage. Today, it is well-known that the harmful substance is hydrogen sulfide or sulfidric acid, a colorless gas that at low concentrations smells like rotten eggs. It is formed by bacterial decomposition of animal and vegetable proteins and is present in the processes carried out near marshes, swamps, sewers, and cesspools [18]. Exposure to the gas results in eye damage, although it is controversial whether prolonged exposure causes irreversible damage and blindness [19].

Fifth, he reported some simple palliative remedies based on the worker’s experience, suggested some possible preventive measures of dubious effectiveness, and recommended giving up that activity which, if continued, would have led to blindness.

Ramazzini’s observations and comments summarize some relevant elements that are still valid today for assessing health risks: (1) clinical characteristics—the observation that a health effect can occur after short or long-term exposure (evidence of acute and chronic toxicity); (2) epidemiological characteristics—analysis and ascertainment of an effect both in individual workers and in groups of workers (individual and group approach); (3) toxicological features—the relationship between the length of exposure and the effect/response is the hallmark of any toxicological investigation (dose-effect and dose-response relationship).

An exploration through the working world at the time

Starting from the examination of working techniques and description of disorders, Ramazzini systematically gathered information and acquired useful experiences to write a treatise on illnesses caused by work [14, 20, 21]. This approach, based on the observation of pathological events in groups of workers and not only in individuals, shows the originality of a doctor who, as a clinician, had dealt with individual patients only. He explored a large number of worksites and identified a large number of occupations and jobs in many working environments (Figure 2). Although it is difficult to analyze the importance of his observations in the light of current knowledge, it is important

Figure 2. The first 2 pages of the list of workers whose diseases are mentioned in the 1713 Diatriba Syllabus artificum de quorum Morbis fit mentio [8]. The Syllabus lists 67 occupations and jobs. The book includes 54 chapters (40 chapters numbered 1–41, chapter 8 is missing, the Dissertation of Learned Men, 12 Chapters of the Supplementum, and the Dissertation on nuns’ health). Nevertheless, the number of occupations is higher since many chapters deal with more than one job. Chapter xvii, for example, which deals with oil-pressers and tanners, takes into account several other jobs, such as fiddlerstring-makers, butchers, fishmongers, salters, cheese-makers and tallow chandlers; chapter xxv includes stone-cutters, quarrymen and sculptors; and chapter xxx includes carpenters, carvers, blacksmiths, and masons. Careful counting of all occupations mentioned throughout the Diatriba reaches a total of 138 different types of work.
to acknowledge some aspects of his work even from a superficial perspective.

**Diseases associated with occupational and environmental hazards**

As for his clinical observations, Ramazzini described many disorders caused by specific work-related risk factors and classified the diseases according to the type of job. The *Diatriba* describes several morbid forms, such as dust-related lung problems and severe neurological disorders associated with exposure to lead and mercury [13, 22]. He reported still-existing clinical pictures and important widespread health problems, such as bronchopulmonary pictures such as asthma [23] and hypersensitivity pneumonitis, and understood the underlying pathophysiological mechanisms [24]. He also observed disorders associated with the sensory system, such as noise deafness in shipbuilding carpenters and visual fatigue problems in people making small objects [25].

Much space in the *Diatriba* is dedicated to illustrating musculoskeletal disorders in workers employed in many jobs. It lists workers in 26 different occupations, from brick-makers to sailors and from printers to writers and notaries, suffering from all kinds of musculoskeletal disorders [26]. Ramazzini found that several morbid pictures were associated with postures, movement repetition, weight lifting, and muscular load, which today we would define as ergonomic factors [27]. Ramazzini clearly identified stressful circumstances. He detected in accounting clerks, in addition to the continuous sitting, the mental strain to avoid mistakes or cause loss to their employers, and keenly noted that an intense application of the mind harmed those workers [13].

He devoted attention to inequality and above all to vulnerability, and described health-related problems in two vulnerable groups: ethnic minorities of that time and women. Women were committed to the production of commodities such as pasta, bread and clothing items, but they were also commonly employed in different occupations involving exposure to dangerous materials and ergonomically demanding work such as agricultural jobs and transport of stones and bricks [28].

Ramazzini described severe chronic diseases mostly in heavy occupations such as mining, and also made an explicit reference to tumors. He found that nuns developed breasts cancers more often than any other women, and explained that it was related to their celibate life. This remark anticipated by centuries the observation of the relationship between nulliparity and hormonal status in women [28]. For this observation, Ramazzini has been recognized as a precursor in research for the prevention of neoplastic diseases [29].

The *Diatriba* concisely describes an episode of pollution associated with pathological pictures affecting the inhabitants who resided near the polluting site, thus revealing that Ramazzini's attention was not limited to the working environment but also extended to the context of life. The episode confirms the value of the scientific approach with which Ramazzini tackled the subject by valuing the observation of unexpected health damages. Even today, these observations remain startlingly relevant and represent an alarm signal as a potential environmental problem of interest for public health. These remarks have been valued as they anticipated modern epidemiological tools in work and living environments [30].

**Prevention of occupational risks and health promotion measures**

Ramazzini's interest was not limited to detecting workers' ailments and describing clinical aspects of diseases, as he was more concerned with prevention, as shown by his statement that prevention is far better than cure [31]. His identification of hazards allowed him to propose preventive measures to protect workers' health. He suggested several measures that are well-established today, such as removing polluted air emitted by minerals and warning about working in spacious places to limit dust pollution [14]. Related to what today is called organizational control, such as reducing the working hours to limit exposure to risk factors, he recommended workers to avoid the same posture for a long time by exercising the body, and repeatedly advised them to be moderate [27, 32]. As for individual protection equipment, he suggested using personal tools, such as stuffing the ears with cotton to cancel out loud noises, and the use of mouth and nose coverings against inhalation of dusts [13].

Another event, which saw Ramazzini as a protago-
nist, should be remembered in the field of preventive measures. The event involved a rinderpest epidemic, a highly contagious panzootic affecting livestock, which occurred in the early 18th century. That event shares many similar aspects with the COVID-19 pandemic. While significant efforts for COVID-19 are currently underway to implement effective enforcement measures, similar efforts were also made for the livestock epidemic. Ramazzini and other scholars were asked to investigate the pressing public health issue and offer solutions [31]. The final report recommended preventive measures that included the lockdown of infected animals, and the health authorities restricted the marketing of livestock and the freedom of movement of people who had been in contact with infected animals [31, 33].

In addition to work-related health problems, Ramazzini also paid close attention to the lifestyle behind such problems by encouraging healthy behaviors. He believed that exercising the body was the best thing to combat a sedentary lifestyle, and prescribed it first of all. Although the second half of the 17th century was a time of severe famines and manual workers had just frugal livelihoods, Ramazzini reminded wealthier people that those who led a sober and simple life would live longer and would suffer less from obesity [34]. He considered tobacco smoking to be a bad habit, and predicted that the vice would always be condemned and yet always maintained [35]. He claimed that an unreasonable intake of wine was harmful to health, and he also drew attention to the psychological damage that its abuse could cause, in addition to the physical damage. These warnings show that he rightly foresaw the idea of considering workplaces as a privileged place to actively involve workers in health promotion programs with the aim of improving their well-being by addressing a sedentary lifestyle, lack of physical exercise, food intake, and any abuse [36, 37].

Conclusion

The Diatriba was composed in the years when the Age of Reason began to focus on public health issues by putting the ideas of that cultural movement into practice [38]. The book enjoyed success after its publication. Originally written in Latin, which was the erudite language of the time, it was translated into many other languages [39]. Although the book had a wide circulation among the most educated people and scholars, Ramazzini’s teaching was ignored, and nearly no measures were taken to improve working conditions. The time had not yet come to implement measures to protect workers’ health, and the Diatriba was forgotten until the nineteenth century, when new health problems were thrust up by the Industrial Revolution [39]. Many years later, and even in recent times, the lessons of Ramazzini have been considered worthy to be resumed [40–44].

While it is not easy to assess and compare observations and discoveries made at different historical times, the evaluation of the relationship between past observations and present practices is a source of stimulus and encouragement to improve the present. The originality and innovative nature of Ramazzini’s studies assume particular importance in light of current topical issues, ranging from health problems related to lifestyle habits to the current serious COVID-19 pandemic. Recent papers aim to remind the upcoming generations of occupational health professionals of the importance of the discipline’s roots by emphasizing their relevance to current conditions [34, 45]. Doctor Ramazzini’s lesson is always alive and provides a role model for doctors and all occupational health professionals.

Conflict of Interest
None

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