

COVID-19 in meat plants: a survey framed within a Target Prevention Plan, in Italy

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Abstract

Background. During the COVID-19 pandemic, several outbreaks have been recorded worldwide in industrial slaughterhouses and meat-processing plants. Competent Italian health authorities at regional and provincial levels agreed on a risk-oriented control plan.

Methods. Advocacy actions were activated, targeting meat plant managers and related food business operators. A questionnaire focused on the inventoried risk factors from literature was developed and administered voluntarily to interested stakeholders. In addition, an outbreak questionnaire was proposed to the prevention department of local health units.

Results. From 2021 to 2022, 333 advocacy and 24 outbreak questionnaires on 4,765 inventoried plants were collected. The lack of awareness in updating the Risk Assessment Document for COVID-19, non-instrumental body temperature checks at the entrance, working force from different subcontractors, poor hygiene in shared places, and insufficient ventilation were the main critical points recorded.

Conclusions. Results provide a *post hoc* review with an eye toward future zoonotic pandemics.

Key words

- COVID 19
- meat plants
- target prevention plan
- survey

INTRODUCTION

During the COVID-19 pandemic, it has become increasingly clear that some occupational non-healthcare settings could be vulnerable to outbreaks, such as meat plants (slaughterhouses, meat processing, and cutting plants), where the combination of environmental, social, and working condition factors represent a driver for contagiousness among workers [1] and extend in some cases to relatives in residential settings [2]. Since 2020, rapid and large-scale COVID-19 outbreaks in high-throughput industrial meat plants with a working force of up to 20,000 workers have been reported in the United States, Canada, and the European Union [3-5]. Epidemiological investigations have increasingly elucidated the risk factors that facilitate entry and per-

sistence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the workspace and its spread among workers, such as: a) workforce recruitment and turnover, collective transport systems to/from the workplace, and housing [6-8]; b) workplaces with poor ventilation and insufficient fresh air exchange; c) presence of aerosol/vapours able to transport the virus well above the 1-2 m distance prescribed among workers; and d) cool surfaces where virus particles could condense and persist for days [9]. As industrial slaughterhouses are critical in ensuring the meat supply chain from farm to fork, COVID-19 and other disease outbreaks in such essential settings for the food chain represent a food insecurity factor. Postponing the slaughtering of poultry and pigs for only a few days can compromise animal

welfare and meat quality, making meat production less cost-effective and causing food waste. In addition, the presence of the SARS-CoV-2 genome on the surface of packaged meat [10, 11] has been a matter of international import/export dispute within the World Trade Organization [12], thus causing food chain disruption.

In this study, we aim to describe the results of a targeted COVID-19 prevention plan in meat plants in Italy, set up at the end of 2020. Such a target prevention plan designed based on the first epidemiological evidence in Italy and abroad has been proposed to regional and provincial health authorities for adoption and implementation despite the urgent priorities in the healthcare territory setting determined by the evolution of the pandemic in Italy.

In Italy, preventive medicine in occupational settings has been assigned to Regions and Provinces under the coordination of the Italian Regions Conference, technically supported by the Working Group (WG) on "Health and Safety at Working Places". This WG has the mandate to propose the activation of the so-called "Target Prevention Plans" to the Regions and Provinces; these plans consist of an advocacy action with the stakeholders to reach priority and risk-oriented targets of health prevention in the working places.

Figure 1 illustrates the activation steps of this plan in the context of the recorded pandemic curve in healthcare and non-healthcare workers in Italy from official data (<https://www.epicentro.iss.it/coronavirus/sars-cov-2-dashboard>).

MATERIALS AND METHODS

Set up of questionnaires for COVID-19 occupational health in meat plants and study design

Within this framework, in April 2020, the Istituto Superiore di Sanità (ISS, Italian National Institute of Health), a technical scientific institution of the Ital-

ian Health System, contacted the local health unit of the Bari-Apulian region, which reported the first COVID-19 outbreak in a meat plant [13]. Based on the evidence from the field and those reported in the scientific literature, an advocacy webinar was organised in September 2020, with the involvement of meat plant associations and national, regional, and provincial authorities, to share evidence and experiences. The outcome was the proposition of three different tools to support a targeted COVID-19 prevention plan in meat plants: 1) a questionnaire addressing the critical control points to be considered for the prevention and risk assessment of COVID-19; 2) a second questionnaire addressed to local health authorities for the reporting of COVID-19 outbreaks; and 3) a harmonised checklist for official inspection by competent local authorities at meat plants. After the first on-field validation, the first two questionnaires were published with Italian and English versions in the COVID-19 Reports edited by Istituto Superiore di Sanità [14] (see *Supplementary Material available online*). A descriptive and observational study design based on voluntary participation to the initiative by private meat plants owners was then set up. Italian Meat Plant Associations were asked to inform their members of the opportunity to participate in such surveys voluntarily. Online questionnaires were made freely available to stakeholders via the Google Modules platform under the national General Data Protection Regulation (GDPR). The responses to the advocacy and outbreak questionnaires were collected from the end of December 2020 to the end of December 2022. The distribution of responses (frequency analyses) were reported as results in this study. In *Figure S1 available online as Supplementary Material* the flow diagram illustrates the network between the main health-related stakeholders and COVID-19 prevention activities in workplaces in Italy.

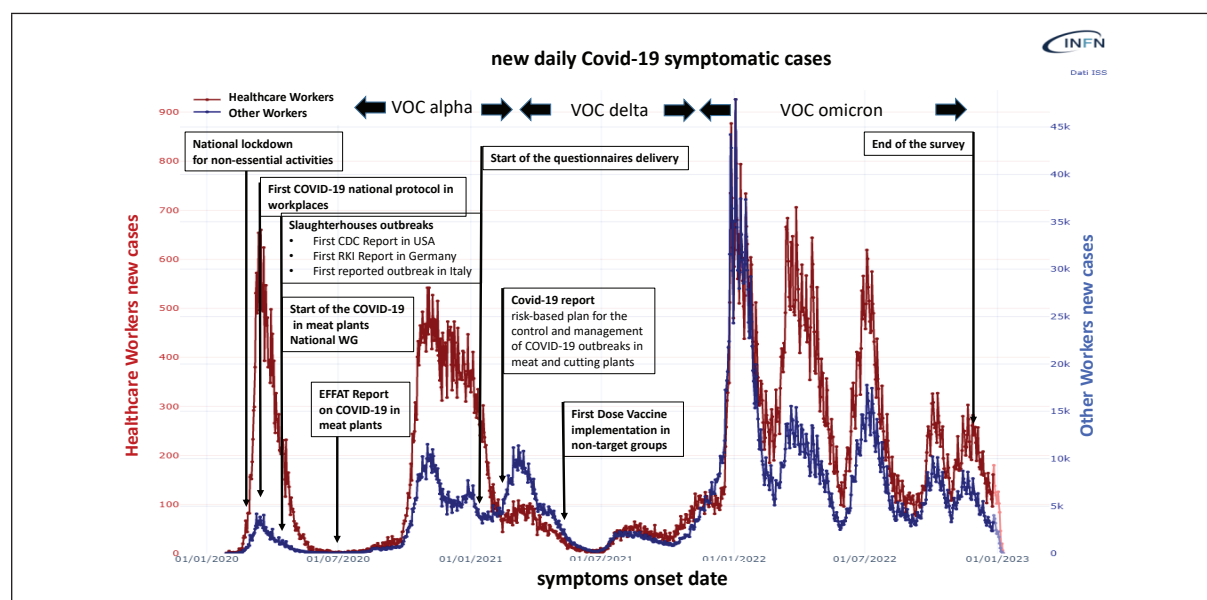


Figure 1

COVID-19 pandemic curve in Italian workers, along with the events leading to the activation of a target prevention plan in meat plants, in Italy.

RESULTS

Critical control points to be considered by meat plant management

Meat plant profiling and workforce

During the two-year timeframe (2020-2022), we recorded 333 completed and validated COVID-19 awareness questionnaires from 4,675 slaughterhouses and meat cutting and processing plants inventoried at the central level by the competent authorities (<https://www.dati.salute.gov.it/dati/dettaglioDataset.jsp?menu=dati&idPag=8>). The platform recorded submitted modules, only: no information about access number and time spent on the platform were available. The geographical provenance of such modules largely acknowledges the Italian Regions/Autonomous Provinces that have explicitly declared their interest in such a Targeted Prevention Plan. Lombardy (N=140); Veneto (N=95); Trentino (N=37); Calabria (N=29); Apulian (N=11); Piedmont (N=9); Emilia-Romagna (N=6); Sardinia (N=3); Lazio, Sicily, and Umbria each (N=1). We report different plant settings that, in some cases, acknowledge the presence of a cutting plant associated with the slaughterhouse and activities addressed to different animal species in the Supplementary materials (Table S1 available online as Supplementary Material).

Most of the responding plants indicated that their operations were not extended on all 6-7 working days. This implies that the workforce was mostly unshifted on the same working day (N=302; 91%). Two and three working shifts/d were recorded for 5% and 2% of the plants, respectively. Missed answers =2%. The details are presented in Table 1. Non-permanent staff (cooperatives, third parties, and autonomous workers) were present in 42% of the companies (N=139). Cooperatives are regularly present in 125 plants. Of these, 52, 36, 18, 10, and 9 plant managers engaged 1, 2, 3, 4-5, and ≥6 cooperatives, respectively. Non-permanent staff are generally spread across different activities, from livestock handling to cleaning and packaging. The overall number of workers (permanent and non-permanent) in the responding plants is reported in Table 1.

Table 1
Working days per week (left) and number of workers in those plants participating to the survey (right)

Working days	S	PC	S+PC	Total	Workers	Plants
1	54	8	4	66	N	N
2	61	7	4	72	1-5	105
3	15	8	2	25	6-10	52
4	14	7	3	24	11-25	55
5	45	60	7	112	26-50	31
6	13	13	7	33	51-100	15
7	1	-	-	1	>100	42
Total	203	103	27	333	missed	33

S: slaughterhouse; PC: processing/cutting plant; S+PC: slaughterhouse and processing/cutting plant; N: number; missed: data not available.

Preventive measures at the workplace and personnel management

All responding plant managers declare that workers have been properly informed about the preventive measures in case of suspicion of COVID-19 (such as staying at home if symptomatic, calling the appointed physician of the healthcare system, alerting the plant staff if symptomatic at the workplace and avoiding close contact, and following rules to prevent contagiousness at the workplace). A regular instrumental check of the body temperature at the entrance of the plant was reported in 73% of the answers (243/333). Fifty-six (17%) required self-declaration, while one omitted this procedure. A total of 10% had missed or inconsistent answers. Separate and time-shifted entry and exit for workers and visitors were present in 92% of the cases (305/333), whereas dedicated toilets were present in only 37% (123/333).

Visitors were not informed about preventive measures in 19/333 cases (9%), and checks on the appropriate and regular application of preventive measures were not fully implemented in 123/333 plants (37%). Regular cleaning and sanitisation of shared places, changing rooms, and canteens were in place in 95% of the plants, with daily frequencies in 59% of cases, three/four times a week in 15%, and once/twice a week in 15%. The remaining 1% reported cleaning and sanitisation intervals of >7 days.

Accessible and easy-to-find handwashing dispensers were declared in 99% of the prevention questionnaires. Personal Protective Equipments (PPEs) were declared always available in 83% (278/333) of the cases when inter-personnel distances were less than 1 meter, according to the national guidelines issued by the Italian Government on March 20 (Decreto del Presidente del Consiglio dei Ministri 11 marzo 2020), and the technical updated on April 2020 by the National Institute for Insurance against Accidents at Work (Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro INAIL), a public, non-profit entity safeguarding workers against physical injuries and occupational diseases (see Supplementary Material available online) (<https://www.inail.it/cs/internet/docs/alg-pubbl-rimodulazione-contenimento-covid19-sicurezza-lavoro.pdf>). In 16 cases (5%), because the worker's distance was greater than 1 m, the answer was negative. Missed or incorrect answers accounted for 10% of all answers. PPEs were reported to be changed daily in 99% of the cases, and information and instructions about its proper use/wearing were present in 95% (315/333). Details about the PPE used in the plants according to the workforce are present in 293 questionnaires are shown in the Table S2 available online as Supplementary Material.

Appropriate workplace organisation to maintain the prescribed minimum distance of 1 m between workers was implemented in 53% (173/333), whereas in 41% (135/333), the implementation of such measures was reported to be not necessary. The remaining 6% of the plants provided either negative or missing answers.

The presence of physical barriers between workers was present in 116 answers (35%), while in 50% of the cases, the absence of a specific need was declared.

The time zones at the entrance and exits were designed to meet the 1 m distance requirement in 50% of the plants (168), while in 143, this was not the case. Negative answers accounted for 7% of the responses (23). Staggered shifts to the canteen and shared places were present in 87% of the cases (290).

Smart working was implemented in 63 plants (19%) for non-essential activities; a personnel turnover plan to reduce contact was implemented in 71 plants (21%), and not in the remaining 263. Social valves in case of absence from work due to COVID-19 were present in 86 plants (26%). In 164 cases (49%), workers were asked to take holidays, with negative or missing answers for the remaining 25%.

The activation of a committee (with occupational health responsibilities and trade union representatives) (*Figure S1 available online as Supplementary Material*) in charge of verifying the application of COVID-19 preventive measures was noticed in 171 plants (51%), and the COVID-19 update of the mandatory document on risk assessment was noted in 83% of the answers.

Ventilation and vapour/aerosol formation

In *Table 2*, we report the recorder answers to the questions related to ventilation according to the different plant premises.

Regular maintenance of heating, ventilation, and air conditioning (HVAC) filters is declared in 90% of the plants, whereas records of ventilation maintenance are reported in only 50%.

In 287 plants (86%), high-pressure water jets were used for cleaning workspaces. Among these, 65 plants (20%) reported performing such operations in the presence of workers. In pig slaughterhouses, scraping was performed using hot water baths (N=94), steam and water (N=7), singeing (N=52), brushing and showering (N=43), and infrared beams (N=7). The missing responses accounted for 33. In scraping activities where water was used, 80 answers reported such procedures in the presence of workers. The distance from the vapour/aerosol source was <1 m in seven plants, >1<2 m in 38, and >2 m in 35. Aspiration systems were used in place of the 59/89 plants. In poultry slaughterhouses, the use of water as a proxy for vapour generation for animal electric stunning is reported in 23/32 plants. Nebuliser systems to improve animal welfare in the pre-slaughter

area and lairage were present in 42/230 slaughterhouses and in nine cases in the presence of workers.

Results from outbreak questionnaires

Within the 2021-2022 time frame, 24 validated outbreak reports were voluntarily received from the officers of the preventive departments of local health units. *Table 3* reports the descriptors of the outbreaks; the corrective measures taken are shown in *Table S3 available online as Supplementary Material*.

DISCUSSION

The main objectives of the questionnaires were: a) to provide a technical guidance document to harmonise and risk-orient the activities of the local Health Prevention Departments on the national territory; b) to increase the awareness of meat plant managers and related food business operators to prevent COVID-19 in meat plants in an evidence based way; and c) to cover the knowledge gaps about the main risk factors in meat plants at national level. Despite meat plant companies reporting the implementation of measures to address COVID-19 in accordance with national guidelines, such as promoting physical distancing in communal areas, installing barriers, and mandating the use of masks, epidemiological evidence indicates that the risk of COVID-19 transmission to workers in large meat plants is significantly higher than that for the general population of the district/state/region [15].

Consequently, as a first step towards the initiation of a targeted prevention plan at the regional/provincial level in Italy, it seemed worthwhile to propose an advocacy questionnaire to stakeholders in meat plants and to provide feedback on the information gathered. Although not generalizable to all on-field situations, the results from advocacy questionnaires offer insights into the occupational health risk faced by meat and poultry workers during the COVID-19 pandemic. These findings are consistent with those from identified studies and other research-based sources on various topics relevant to our paper. The main feature of Italian slaughterhouses and processing/cutting plants is their large numbers (N=4,675 officially registered). Among them, approximately 20 plants have a working force from 500 up to 2,000, and in the poultry sector, six industrial plants account for 90% of the national production. Within this framework, the reduced workforce in most of the plants, along with activities not conducted throughout the week (*Table 1*), represent mitigating factors with respect to COVID-19 spread and related outbreaks reported in large industrial plants as higher worker density coupled with longer stay in the workplace because of overtime, as already noted by Dyal *et al.* and Waltenburg *et al.* [3, 4]. However, the widespread presence of plants in Italy hampers the capillary monitoring activity of the preventive COVID-19 procedures in place. It is worth noting that during the pandemic (*Figure 1*), the professional resources of the prevention departments of the local health unit in charge of health prevention in the workplace were preoccupied with other health priorities such as contact tracing, testing, and vaccination. Therefore, advocacy activities based on a targeted

Table 2
Number of natural ventilation vs mechanical heating, ventilation, air conditioning (HVAC) in the premises of 333 meat plants: between (brackets), the number of premises with HVAC air recycling >30%

Premise	Ventilation		
	Natural	HVAC	HVAC Not reported
Working area	234	91 (26)	8
Offices	306	8 (2)	19
Changing room	288	25 (7)	20
Canteen	156	17 (6)	160
Shared places	245	24 (7)	64

Table 3

Descriptors of the COVID-19 outbreaks recorded in Italian meat plants, on voluntary basis

Province	Species	Workers (N)			Outbreak dd/mm/yy			Tested workers and results				Report dd/ mm/yy
		Permanent	S_C	T_W	Start	End	Days	Tested	Positives	%	Agencies (N)	
Trento	S (S)	210	2	40	09/09/20	02/10/20	22	169	33	20	3	04/12/20
Napoli	S (P)	195	2	0	28/08/20	10/10/20	41	195	87	45	2	15/12/20
Trento	S (S)	206	3	71	08/09/20	23/09/20	15	140	33	24	4	05/01/21
Trento	CP (S)	119	4	71	01/09/20	23/09/20	22	122	81	66	5	05/01/21
Trento	S (S)	36	2	42	16/09/20	05/10/20	19	36	25	69	3	05/01/21
Trento	CP (na)	35	5	71	04/09/20	23/09/20	19	35	13	37	3	05/01/21
Bari	S (C, S, SR, H)	13	0	0	03/11/20	30/11/20	27	15	4	27	1	14/01/21
Bari	S (C, S, SR, H)	50	0	0	13/11/20	20/12/20	37	50	6	12	1	03/02/21
Treviso	S (C, H)	19	5	26	20/11/20	27/11/20	17	18	0	0	1	12/02/21
Bari	S (C, S, SR)	438	7	71	23/04/20	19/05/20	26	487	112	23	7	26/03/21
Treviso	S (C)	180	5	50	17/11/20	10/12/20	23	43	20	47	1	27/04/21
Venezia	S (P)	122	2	6	28/10/20	10/01/21	12	180	49	27	2	19/07/21
Ragusa	S (P)	205	2	na	05/11/20	02/12/20	27	205	12	6	1	15/09/21
Ragusa	S (P)	250	2	na	30/03/21	30/06/21	90	57	8	14	1	16/09/21
Mantova	S (S)	350	4	65	29/06/20	15/07/20	16	350	50	14	5	04/10/20
Mantova	S (S)	184	5	56	10/07/21	30/07/21	20	184	10	5	3	19/01/21
Mantova	S, CP (S)	350	2	60	10/06/21	25/06/21	15	123	38	31	2	30/09/21
Mantova	CP (na)	15	1	17	30/06/20	13/08/20	44	15	7	47	2	04/11/21
Mantova	S, CP (C, S)	150	1	6	22/02/21	05/04/21	44	152	5	3	1	29/09/21
Mantova	S (S)	270	3	40	16/08/21	24/08/21	8	8	1	13	3	20/10/21
Mantova	CP (na)	400	2	5	26/07/21	16/08/21	20	30	6	20	1	27/09/21
Mantova	S (C)	270	6	70	04/04/20	29/10/20	25	267	47	18	4	05/11/21
Padova	S (P)	45	2	20	22/10/20	09/11/20	18	27	9	33	1	10/08/21
Reggio C.	S (C, S, SR, H)	7	0	0	01/01/21	30/06/21	180	7	7	100	1	26/09/22

S_C: subcontractors; T_W: temporary workers; na: not available; S: slaughterhouse; CP: processing and cutting plant; C: cattle; S: swine; P: poultry; SR: small ruminants; H: horses; agencies: N of companies recruiting temporary workers; N: number.

prevention plan seem more appropriate and practicable. The results presented in this paper do not cover all the initiatives taken to prevent and manage COVID-19 outbreaks in meat plants in the national territory. For instance, the Emilia Romagna Region independently activated cultural mediators to inform and form non-Italian workers about procedures to be adopted to lower the risk (such as quarantine period back from holidays in the country of origin, priority in the diagnostic tests, and then, support for vaccination), as reported in a Canadian-Ontario case [8]. The shared knowledge of such preventive measures and actions in a webinar organised in September 2020 by Istituto Superiore di Sanità, with the participation of representatives of meat plant associations and health stakeholders, contributed to the questionnaire setup.

The participants (N=333) in the advocacy questionnaire represented 7% of the registered plants in Italy and

were mostly located in those districts whose regional/province health authorities agreed to activate targeted prevention (Lombardy, N=140; Veneto, N=95), according to the flow diagram reported in *Figure S1 available online as Supplementary Material*. Support at the local level has also been determined by the high social and economic benefits of processed meat products (such as ham and salami) from such geographical areas. The reduced dimensions of meat plants in Italy may have contributed to a reduced perception of the relevance of the initiative, thus limiting voluntary participation in the survey. In the United States, a survey on COVID-19 in slaughterhouses reported the active participation of 28 out of 50 states (56%), accounting for an average of 3,500 meat plants with an overall workforce of 525,000 workers [4].

Despite only 7% adherence to the Italian initiative, the answers recorded from the advocacy questionnaire

reflected the presence of structural, environmental, and management risk factors, as reported in the literature [16-18].

Workforce management, with non-permanent staff (cooperatives, third parties, and autonomous workers) present in 42% of the companies (N=139), indicates the risk of the formation of non-homogeneous teams as a factor that could facilitate contagiousness within the same work shift. This critical factor found feedback in 24 reported outbreaks, where, on average, three cooperatives (min/max=0-6) were present (Table 3). In personnel management, a combined risk indicator for the entrance and spread of COVID-19 among workers includes the number of animals slaughtered/processed daily, the number of time shifts per day, and data on the external workforce. Within this framework, the answers about the instrumental check of body temperature at the entrance recorded in only 27% of the plants represent another weak point of the preventive action, especially in the presence of a pandemic R_t well >1 in the general population. The mitigation of risk in the workplace also relies on appropriate information and formation of the workers, along with the verification of whether the preventive measures are correctly put in place, and last but not least, the activation of COVID-19 illness social valves (in our survey, present in 26% of plants only). Again, the relevance of such factors has been highlighted by the evidence from outbreak management (Table S3 available online as Supplementary Material), where the plant responsibilities had to reinforce the checks, redraft the entrance and exit paths of workers and external personnel, improve information and formation (42% of the reported outbreaks), and provide devices for better personal hygiene (38% of the cases).

The overall need for advocacy activity towards the real adoption of COVID-19 preventive measures and the check of their correct application by meat plant management is highlighted by the recorded delay in the establishment of the meat plant committee formed by occupational safety responsibilities and trade union representatives in charge of this task (51% of positive answers), despite the COVID-19 update of the mandatory document on the risk assessment recorded in 83% of the answers (Figure S1 available online as Supplementary Material). In this respect, the recorded generation of vapour and aerosols in some working areas according to each plant structure should not be overlooked in the updated plant document on risk assessment. This is because it has been demonstrated that SARS-CoV-2 can reach distances well over the minimum prescribed by workers (1-2 m) in the presence of vapours and aerosols, as reported in industrial slaughterhouses in Germany [19]. This represents a risk factor, especially if vapour/aerosol-exposed workers do not wear adequate PPEs (Table 2).

Ventilation with adequate natural air exchange represents another preventive measure stressed in the advocacy questionnaire, as it has been demonstrated that the relative percentage of CO₂ can be used as a proxy for insufficient indoor air exchange [16, 20]. When air is recycled, a recycling percentage >30% may be inadequate for prevention, particularly when adequate filtering systems are not in place. A high percentage of re-

cycled air may acknowledge seasonal trends as a matter of energy savings policies to keep the room temperature adequate for the specific activities of the working area (e.g., chilling or air warming during summer or winter). For this purpose, structural modifications of ventilation were considered in six out of 24 cases in the management of outbreaks (Table S1 available online as Supplementary Material). Such a measure has been associated with increased interworker distance in 17% of the cases. Finally, in the presence of an HVAC system, the air flux in the working area must be addressed correctly.

Considering the reported outbreak dates, it is worthwhile to fix July 20 as a discriminant for the COVID-19 vaccination campaign extended to the Italian general population (including meat plant workers). Before this date, vaccines were administered to fragile persons and the most exposed worker categories, such as those working in healthcare settings, schools, and police forces. We registered 14 outbreaks before and 10 outbreaks after the start of the COVID-19 vaccination campaign extended to the Italian general population. This means that vaccination alone could not represent effective prevention in such settings, but it should accompany all the supporting preventive measures, especially when the workforce is largely non-autochthonous [8].

The outbreaks lasted on average 26 days (one outlier data of 180 days excluded) (Table 3), with an overall 26% positivity rate among workers, in line with the prevalence reported in other studies: 3-24% from Waltenbur et al. [4], 18% from Di Leone et al. [13], 26% from Steinberg et al. [21], 30-40% from Vanderwaal et al. [22], 12-16% from Pokora et al. [9], 33% from Walshe et al. [16], and 36% from Finci et al. [17]. Of interest are the five outbreaks reported in the Trentino-Alto Adige Province, where almost the same cooperatives were turned over among the plants involved (Dario Huber, personal communication).

Among the reported outbreaks, the description of the widest Italian outbreak that occurred in a poultry slaughterhouse and cutting plant (August to September 20) was missing. From publicly available information, as reported on the website of the Veterinary Trade Union of the Veneto Region, positivities included 200/675 workers belonging to 12 different nationalities, and the massive and intensified screening with rapid tests allowed a 50% reduction in the activities, instead of their full withdrawal (<https://www.sivempveneto.it/covid-19-focolai-in-impianti-di-macellazione-il-sivempveneto-massima-attenzione-alla-sicurezza-dei-veterinari-ufficiali-protezioni-e-screening-costanti/>).

This evidence underscores the necessity of establishing standardized actions, akin to those implemented for healthcare workers, to enhance the protection of worker health in meat plants, thereby minimizing associated social and economic consequences. Figure 2 shows the cross-cutting aspects of the prevention activity at meat plant level for COVID-19 with Sustainable Development Goals Nos. 1, 2, 3, 8, 9, 10, 12, and 17 proposed by the United Nations. Consequently, as a first step towards the initiation of a targeted prevention plan at the regional/provincial level in Italy, it seemed worthwhile to propose an advocacy questionnaire to stakeholders

**Figure 2**

Impact of the activation of a target prevention plan in meat plants on the Sustainable Development Goals Nos. 1, 2, 3, 8, 9, 10, 12, and 17 proposed by the United Nations.

in meat plants and to provide feedback on the information gathered. Although not generalizable to all on-field situations, the results from advocacy questionnaires offer insights into the infectious challenges faced by meat and poultry workers during the COVID-19 pandemic. These findings are consistent with those from identified studies and other research-based sources on various topics relevant to our paper [23]. Key lessons learned from this initiative can be summarized as follows:

- *regional and provincial prioritization*: the proposal for the activation of a COVID-19 prevention plan in meat plants in Italy was not uniformly selected as a priority by all Regional and Provincial Health Authorities. This decision appears to be influenced by the fluctuating COVID-19 pandemic curve in different territories. Consequently, the responses received from the advocacy questionnaire may not reflect the outcomes following the full activation of targeted prevention plans at the local level;
- *voluntary participation limitation*: the voluntary nature of meat plant owners' participation in the initiative posed limitations on the representativeness of the results at the national level. Additionally, this voluntary approach hindered the ability to test a priori hypotheses or draw inferences from the data, as the questionnaire was completed on a voluntary basis;
- *complexity of advocacy questionnaire*: the complexity of the advocacy questionnaire, designed to consider a combination of various environmental, social, and working condition risk factors specific to meat plants, may have restricted participation to the most motivated stakeholders. The absence of specific guidelines for the meat plant sector might have contributed to this limitation.

These observations highlight the importance of addressing regional variations in priorities, considering strategies to enhance participation, and refining ques-

tionnaire design for a more comprehensive understanding of the challenges associated with COVID-19 prevention in meat plants

CONCLUSIONS

In conclusion, the proposal for a Target Prevention Plan on COVID-19 in meat plants, supported by specific guidelines and advocacy questionnaires, stands as a valuable tool to standardize and risk-align the activities of health prevention departments across the national territory. The integration of results from both advocacy and outbreak questionnaires facilitates a comprehensive assessment, providing stakeholders with insights into critical points for implementation in terms of preparedness. This process contributes to an effective after-action review for essential work settings in the food chain, beyond those directly associated with healthcare services.

Recognizing COVID-19 as an "emerging infectious disease of probable animal origin", meat plants and related settings emerge as multifaceted environments encompassing health, culture, society, economy, and food safety/security. Within this context, the adoption of "One Health" preventive and cost-effective approaches is not only feasible but also essential, as underlined from recent recorded cases of highly pathogenic avian influenza in dairy cattle farms, in the USA (<https://www.fda.gov/food/alerts-advisories-safety-information/updates-highly-pathogenic-avian-influenza-hpai>). These strategies can enhance overall resilience and responsiveness to emerging infectious diseases, reinforcing the interconnectedness of human, animal, and environmental health.

Conflict of interest statement

The Authors declare no conflict of interest.

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