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Assessing vaccine hesitancy and vaccine literacy among the European prison population and staff: A multicentre observational study

D. Petri [a], M. Fornili [b], E. De Vita [a], M.A. Malanima [b], I. Yiasemi [c], J. Mavrou [c], T. Trattonikolas [d], I. Stylianou [d], F. Meroueh [e], E. Murauer [e], A. Mieuset [e], R. Ranieri [f], N. Cocco [f], V. Busmachiu [g], I. Barbirosh [g], L. Tataru [g], S. Doltu [h], S. Mazzilli [a], L. Tavoschi [a], L. Baglietto [b,*], the RISE-Vac Consortium

[a] Department of Translational Research and New Technologies in Medicine and Surgery, University of Pisa, Pisa, Italy
[b] Department of Clinical and Experimental Medicine, University of Pisa, Pisa, Italy
[c] Cyprus National Addictions Authority, Cyprus
[d] Cyprus Prison Department, Cyprus
[e] Centre Hospitalier Universitaire Montpellier, Montpellier, France
[f] Penitentiary Infectious Diseases Service, Santi Paolo e Carlo Hospital, University of Milano, Milano, Italy
[g] National Administration of Penitentiaries of Republic of Moldova, Moldova
[h] NGO AFI Moldova, Moldova

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ABSTRACT

Vaccination is the most efficient and cost-effective public health intervention. Prison population, for its low social distancing, constant turnover, and high percentage of migrants, should be an important target of vaccination campaign. However, vaccination coverage in prison is low. In this study we estimated vaccine hesitancy and vaccine literacy among the prison population and staff and assessed their correlation.

We conducted a cross-sectional study in 13 prisons of 4 European countries. The sample included 847 people living in prison and 755 staff members. Through a structured questionnaire we assessed vaccine hesitancy, vaccine literacy, general health literacy, previous vaccine refusal and socio-demographic characteristics of participants. Exploratory factor analysis was used to extract three components of vaccine hesitancy. Logistic regression was applied to assess the association between previous vaccine refusal and vaccine hesitancy; linear regression was applied to assess the association between vaccine hesitancy and vaccine and general health literacy. All analyses were adjusted for socio-demographic variables.

We identified three components of vaccine hesitancy explaining 49% of the total variance: *Mistrust*, *Concern* and *Conspiracy*. In both people living in prison and staff, all the components were associated to previous vaccine refusal (p-value < 0.001) and presented good internal consistency (Cronbach's alpha $= 0.90$, 0.73 and 0.78). Young participants presented the highest levels of vaccine hesitancy; migrant people living in prison had the lower levels of *Mistrust* and the higher level of *Concern*; all three factors were lower among participants with the highest degree of education. *Mistrust* and *Concern* were inversely associated with vaccine literacy while all three subscales were inversely associated with general health literacy (all p-values < 0.001).

This study suggests that educational interventions aimed at increasing vaccine literacy in people living and working in prison could decrease vaccine hesitation and consequently increase vaccination uptake among the prison population and staff.

Introduction

Vaccination reduces the risk of getting infectious diseases by increasing the body's natural protection provided by the immune system. Currently, vaccines are available for more than 20 life-threatening infectious diseases [1]. Immunisation is the most efficient and cost-effective public health intervention, a key component of primary care and an indisputable human right. Nevertheless, vaccination

* Corresponding author at: Department of Clinical and Experimental Medicine, Via Savi, 10 56126 Pisa, Italy.
E-mail address: laura.baglietto@unipi.it (L. Baglietto).

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coverage is often suboptimal, even in Europe, especially among the most disadvantaged population [2]. Among the causes of the spread of infections, high population density and mobility play a crucial role [3,4]. Prison population, for its low social distancing [5], high and constant turnover and a high percentage of migrants, should be a pivotal target of vaccination campaigns [6]. Vaccination coverage among people entering prison is low, likely due to the combined effect of sub-optimal access to healthcare services and inadequate vaccine and general health literacy [7]. In prison setting, vaccination is still challenging due to vaccine hesitancy and distrust of the institutions of people living in prison [8] and to the controversial issue of allocating vaccine supplies from the institutions and public opinion, as clearly emerged during the recent COVID-19 pandemic [9,10]. Moreover, existing guidelines and policy documents tackling the prevention of communicable diseases in prison settings are generally limited in scope and do not adequately reflect the importance of vaccination as a prevention measure [11].

The RISE-Vac project, co-funded within the 3rd EU Health Program (Project Grants HP-PJ-2020 – https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999999999/project/101018353/program/31061266/details), aims at increasing vaccination uptake among the prison population and staff by improving vaccine literacy through evidence-based educational programs. In the framework of the RISE-Vac project, we have conducted a multicentre observational study on a sample of the prison population and staff in the countries partners of the RISE-Vac consortium. The objectives of the study were to estimate vaccine hesitancy and vaccine literacy in people living or working in prison and assess their correlation.

Methods

We conducted an observational cross-sectional survey between October 2022 and May 2023 in a sample of people living in prison and prison staff in Cyprus, France, Italy and Moldova.

Study sample

Participants were from 1 prison in Cyprus, 3 in France, 2 in Italy, and 7 in Moldova. All members of the custodial staff were invited to participate. For people living in prison, to cope with the logistic difficulties of the operational setting, each centre was advised to enrol an opportunistic sample of residents. Participation was voluntary; all participants signed an informed consent form before enrolment. The competent ethics authorities of each participating country approved the study.

Questionnaires

Questionnaires have been developed to capture vaccine hesitancy, vaccine literacy, general health literacy, and previous vaccine refusal (Supplementary file 1). For vaccine hesitancy, we used the vaccine hesitancy scale originally developed by the SAGE Working Group on Vaccine Hesitancy to capture the hesitancy of parents to vaccinate their children and subsequently validated in English and French [12,13]. We reworded the ten items of the original scale to capture the vaccine hesitancy in adults and added four items: the resulting vaccine hesitancy scale consists of fourteen 5-point Likert scale items, ranging from strongly disagree to strongly agree; eight of the fourteen items were inversely coded, whereby for all items higher scores corresponded to higher levels of vaccine hesitancy. To quantify general health literacy, we developed four items of a 5-point Likert scale with two items reverted, so that for all items higher scores indicated more literacy. To quantify vaccine literacy, we developed eight items with scores + 1 for the correct answer, −1 for the wrong answer, and 0 for no answer.

The questionnaire included one question about previous vaccine refusal (*"Did you ever refused to receive a vaccination?"*) and questions to collect information about age, gender, country of origin, and level of education.

Originally developed in English, the questionnaire was translated in Greek, French, Italian, Moldovan and Russian. For prison staff members the questionnaire was self-administered. Conversely, for people living in prison, the survey could be conducted either through an interviewer or with the assistance of a trained staff member, depending on the policy of each centre (Supplementary Table 1).

Data collection and management

After removing all identifying variables, the data collected through the questionnaires were uploaded in a central database. The anonymized data were transmitted to the study coordination office at the University of Pisa, where data were pre-processed, and statistical analyses conducted.

Statistical analyses

The number of participants needed to obtain the 95% confidence interval (CI) of the mean of vaccine hesitancy with a width of 0.2 standard deviation (SD) is $N_1 = 400$; the number of participants needed to detect a correlation of −0.2 between vaccine hesitancy and vaccine literacy with 80% power at the significance level of 5% is $N_2 = 195$; the number of people needed to detect a difference of 15 percent points in the probability of previous vaccine refusal between those with vaccine hesitancy below the median and those above the median of vaccine hesitancy with 80% power at the significance level of 5% is $N_3 = 350$. Then, the recommended minimum sample size for each study group (people living in prison and staff) was 400, the maximum between N_1, N_2 and N_3.

Categorical variables were described by absolute and relative frequencies; continuous variables were described by means and SDs. For each participant, we calculated the total score of the vaccine hesitancy scale, the vaccine literacy scale, and the general health literacy scale. Visual inspection of the histogram of vaccine literacy scores by prison and group highlighted an excess of participants providing all correct answers (18% with the highest score compared to 2% with the second highest score), suggesting some sort of "*collective cheating*". Then, the values of vaccine literacy of those who provided correct answers to all questions have been replaced with missing. Visual inspection of general health literacy scores did not show any unexpected trend and all records were retained for the analysis. We calculated the 95% CI of vaccine hesitancy for each study group. To assess the validity of the construct of vaccine hesitancy, we applied a chi-square test to compare the proportions of participants that answered "*Yes*" to the question *"Did you ever refused to receive a vaccination?"* in those with values of vaccine hesitancy below and above the median. We calculated the Pearson correlation coefficient between vaccine hesitancy and vaccine literacy in both people living in prison and staff members.

We applied exploratory factor analysis to identify the latent structure of the vaccine hesitancy scale. The scores of the vaccine hesitancy subscales were obtained extracting the factor scores from the exploratory factor analysis. The Cronbach's alpha statistic was used to evaluate the internal consistency of the vaccine hesitancy subscales overall and by study group. For the subscales of the vaccine hesitancy, the Cronbach's alpha was calculated using the items with a factor loading higher than 0.2.

To assess the association between previous refusal to be vaccinated and each subscale of vaccine hesitancy, we fitted a logistic regression model with quartiles of each subscale as predictors; tests for linear trend were performed substituting the quartiles with the pseudo-continuous variables, obtained by assigning to each observation the median value of the corresponding quartile.

To assess the association of vaccine and general health literacy and vaccine hesitancy with the sociodemographic variables, we fitted linear

regression models and calculated the estimated marginal means; we applied the same procedure to quantify the association of vaccine hesitancy with quartiles of vaccine literacy and general health literacy. To account for potential residual confounding effects due to selection bias, we adjusted all regression models for prison's country, and subject's age, gender, study group, and education level.

Sensitivity analyses were conducted by excluding careless participants, that is participants who provided unreliable answers to the vaccine hesitancy section of the questionnaire, identified as those satisfying at least one of the following criteria: high average length of consecutive identical responses, low intra-individual response variability, high Mahalanobis distance [14].

Statistical analyses were conducted using the software R version 4.3.3 [15].

Results

Characteristics of the study sample

The study sample included 847 people living in prison and 755 prison staff members; the mean inmate participation rate for the prisons involved was 11% for France, 12% for Italy and 31% for Moldova (Supplementary Table 1). The majority of participants were from Moldova in both groups (62% in people living in prison and 65% in staff members); among people living in prison, 55% were less than 40 and 4% were older than 60; 88% were males; 41% had a medium–high level of education; 14% were migrants; among staff members, 67% were less than 40 years old and 4% were older than 60; 63% were males; 65% had a medium–high level of education (Table 1).

Vaccine hesitancy

Mean levels of vaccine hesitancy were 37.3 (95% CI, 36.8 to 37.9) in people living in prison and 38.1 (95% CI, 37.5 to 38.8) in staff; the difference between the two groups was not statistically significant (p-value = 0.61). Among people living in prison, vaccine hesitancy was significantly higher in females than males (p-value = 0.006) and decreased with age (p-value < 0.001); among staff members, vaccine hesitancy was heterogeneous by country, higher in men than women (p-values < 0.001), and inversely associated with level of education (p-value = 0.006) (Supplementary Table 2).

Exploratory factor analysis suggested the presence of three subscales in the vaccine hesitancy, explaining 49% of the total variance (Table 2): the first subscale, explaining 27% of the total variance and loading high on eight items associated to mistrust of vaccines and their efficacy, was named *Mistrust*; the second subscale, explaining 14% of the total variance and loading high on seven items associated to high perception of the possible negative consequence of vaccines, was named *Concern*; the third subscale, explaining 8% of the total variance and loading high on six items associated to the fear of conspiracy from the institutions, was named *Conspiracy*. The three subscales presented good internal consistency in both groups: the Cronbach's alpha of the three subscales was 0.90, 0.73 and 0.78 overall (0.88, 0.70 and 0.76 among people living in prison and 0.92, 0.76 and 0.80 among the staff members).

Table 3 reports the associations between vaccine hesitancy subscales and participants characteristics. *Mistrust* was significantly lower among migrant inmates than non-migrant inmates (p-value = 0.01), but no statistical significance was observed between non-migrant inmates and staff (p-value = 0.09); *Concern* in non migrant inmates was lower than in migrant inmates (p-value < 0.001) and higher than in staff (p-value =

Table 1
Characteristics of study participants.

		Country				All
		Cyprus	France	Italy	Moldova	
PEOPLE LIVING IN PRISON		N=0	N=106	N=216	N=525	N=847
Age, years, mean (SD)		–	42.1 (12.9)	42.1 (12.9)	37.2 (10.5)	39.0 (11.7)
Age, N (%)	<30	–	15 (16.0)	43 (19.9)	130 (25.1)	188 (22.7)
	30–39	–	24 (25.5)	48 (22.2)	195 (37.6)	267 (32.2)
	40–49	–	33 (35.1)	59 (27.3)	127 (24.5)	219 (26.4)
	50+	–	22 (23.4)	66 (30.6)	66 ((12.7)	154 (18.6)
Gender, N (%)	Females	–	14 (14.7)	6 (2.8)	72 (14.0)	92 (11.2)
	Males	–	81 (85.3)	207 (96.7)	437 (85.0)	725 (88.1)
	Other	–	0 (0)	1 (0.5)	5 (1.0)	6 (0.7)
Level of education, N (%)	None	–	3 (3.2)	10 (4.7)	192 (37.0)	205 (24.8)
	Primary	–	3 (3.2)	18 (8.4)	260 (50.1)	281 (33.9)
	Secondary	–	80 (84.2)	177 (82.7)	31 (6.0)	288 (34.8)
	Tertiary	–	9 (9.5)	9 (4.2)	36 (6.9)	54 (6.5)
Migrants, N (%)	No	–	82 (88.2)	124 (57.4)	489 (98.8)	695 (86.4)
	Yes	–	11 (11.8)	92 (42.6)	6 (1.2)	109 (13.6)
Vaccine hesitancy, mean (SD)		–	38.7 (8.8)	37.1 (8.4)	37.2 (7.2)	37.3 (7.8)
Vaccine literacy, mean (SD)		–	2.1 (2.0)	2.1 (1.8)	1.5 (2.4)	1.7 (2.2)
General health literacy, mean (SD)		–	12.1 (4.0)	12.3 (3.2)	12.1 (2.9)	12.1 (3.1)
STAFF		N=96	N=77	N=91	N=491	N=755
Age, years, mean (SD)		39.8 (10.4)	38.6 (11.1)	36.3 (11.0)	36.9 (10.4)	37.4 (10.6)
Age, N (%)	<30	12 (12.9)	19 (28.4)	31 (34.8)	115 (23.8)	177 (24.1)
	30–39	39 (41.9)	21 (31.3)	29 (32.6)	224 (46.3)	313 (42.7)
	40–49	29 (31.2)	12 (17.9)	12 (13.5)	89 (18.4)	142 (19.4)
	50+	13 (14.0)	15 (22.4)	17 (19.1)	56 (11.6)	101 (13.8)
Gender, N (%)	Female	30 (32.3)	47 (71.2)	23 (25.3)	169 (35.3)	269 (36.9)
	Male	63 (67.7)	19 (28.8)	68 (74.7)	307 (64.1)	457 (62.7)
	Other	0 (0)	0 (0)	0 (0)	3 (0.6)	3 (0.4)
Level of education, N (%)	None	0 (0)	0 (0)	0 (0)	29 (5.9)	29 (3.9)
	Primary	1 (1.1)	0 (0)	1 (1.1)	229 (46.8)	231 (31.2)
	Secondary	57 (60.6)	14 (20.6)	80 (89.9)	230 (47.0)	381 (51.5)
	Tertiary	36 (38.3)	54 (79.4)	8 (9.0)	1 (0.2)	99 (13.4)
Vaccine hesitancy, mean (SD)		44.2 (10.0)	30.0 (7.7)	37.2 (9.0)	38.4 (8.4)	38.1 (9.3)
Vaccine literacy*, mean (SD)		1.8 (1.7)	4.2 (1.7)	2.6 (2.2)	2.0 (2.2)	2.2 (2.2)
General health literacy, mean (SD)		11.0 (3.0)	16.6 (3.0)	14.6 (2.3)	13.1 (2.6)	13.4 (3.0)

*The values of vaccine literacy in those answering correctly to all questions have been replaced with missing.

Table 2
Exploratory factor analysis of the 14 items of the vaccine hesitancy scale.

		Factor 1	Factor 2	Factor 3
		Mistrust	***Concern***	***Conspiracy***
Proportion of explained variance		0.27	0.14	0.08
Cumulative proportion of explained variance		0.27	0.41	0.49
I1 (Rev) *	Vaccines are important for my health	0.903		
I2 (Rev) *	Vaccines are effective	0.806		
I3 (Rev) *	If I get vaccinated, I protect other people in my community	0.780		
I4 (Rev) *	All the vaccines recommended by the government are good/beneficial	0.562	0.248	0.469
I5*	New vaccines carry more risks than older vaccines		0.509	
I6 (Rev) *	The official information I receive about vaccines from health institutions is reliable and trustworthy	0.563		0.543
I7 (Rev) *	Getting vaccines is a good way to be protected from disease	0.735		
I8 (Rev) *	Generally, I do what my doctor or health care provider recommends about vaccines	0.609		0.237
I9 *	I am concerned about bad effects that vaccines can cause on my health		0.573	
I10 *	I do not need vaccines for diseases that are not common anymore		0.513	
I11	Before vaccination I feel anxious		0.519	
I12	We aren't told about the serious negative/bad effects of vaccines.		0.547	0.288
I13	Above all, vaccines make money for drug/pharmaceutical companies		0.564	0.283
I14 (Rev)	Health organisations provide reliable information on vaccinations	0.337		0.473

Only factor loadings higher than 0.2 are reported.
*Items from the Vaccine Hesitancy Scale developed by the SAGE Working Group (Larson 2015).

Table 3
Association between the three factors of vaccine hesitancy and participants characteristics. Estimated marginal means (standard errors) from the linear models including among predictors all the variables in the table.

		Mistrust		Concern		Conspiracy	
		EMM (SE)	*p-value*	EMM (SE)	*p-value*	EMM (SE)	*p-value*
Group	Staff	0.06 (0.04)		−0.10 (0.04)		0.02 (0.03)	
	Non-migrant people living in prison	−0.04 (0.04)	*0.094**	0.03 (0.03)	*0.011**	−0.01 (0.03)	*0.458**
	Migrant people living in prison	−0.29 (0.09)	*0.012***	0.38 (0.09)	*<0.001***	0.04 (0.08)	*0.571***
Country	Cyprus	1.43 (0.10)	*<0.001*	−0.01 (0.10)	*<0.001*	−0.04 (0.09)	*<0.001*
	France	−0.24 (0.08)		−0.18 (0.08)		0.31 (0.07)	
	Italy	−0.14 (0.06)		−0.25 (0.06)		0.31 (0.05)	
	Moldova	−0.06 (0.03)		0.11 (0.03)		−0.14 (0.03)	
Age	<30	0.12 (0.05)	*0.001*	0.07 (0.05)	*0.007*	0.13 (0.04)	*<0.001*
	30–39	0.01 (0.04)		0.04 (0.04)		0.02 (0.03)	
	40–49	−0.06 (0.05)		−0.05 (0.05)		−0.02 (0.04)	
	50+	−0.17 (0.06)		−0.16 (0.05)		−0.14 (0.05)	
Gender	Female	−0.16 (0.05)	*0.001*	0.00 (0.05)	*0.967*	−0.04 (0.04)	*0.218*
	Male	0.03 (0.03)		−0.01 (0.03)		0.02 (0.02)	
Education	None	−0.03 (0.07)	*0.001*	0.00 (0.06)	*<0.001*	−0.06 (0.06)	*<0.001*
	Primary	0.08 (0.05)		−0.08 (0.04)		−0.01 (0.04)	
	Secondary	−0.01 (0.04)		0.09 (0.04)		0.12 (0.03)	
	Tertiary	−0.32 (0.09)		−0.23 (0.08)		−0.32 (0.07)	

*Test of heterogeneity between staff and non-migrant people living in prison
**Test of heterogeneity between migrant and non-migrant people living in prison

0.01); no significant difference was observed between the three groups for *Conspiracy*. All three subscales of vaccine hesitancy presented a significant inverse association with age, with younger participants being more hesitant than older ones (all p-values < 0.01); males were more vaccine hesitant than females only for the *Mistrust* subscale (p-value = 0.001); no significant difference was observed by gender for the other two subscales; for each of the three subscales, the lowest levels of vaccine hesitancy were observed among participants with high level of education (all p-values <= 0.001).

Constructs validity

In people living in prison, the proportions of those who ever refused to be vaccinated were 19.6% and 57.3% among those with vaccine hesitancy below and above the median, respectively (p-value < 0.001); in staff, the proportions were 24.2% and 55.4% (p-value < 0.001).

The proportion of participants who ever refused to be vaccinated increased with level of vaccination hesitation for either the *Mistrust* component (25% in the first quartile and 65% in the upper quartile; OR = 6.50; 95% CI, 4.32 to 9.78) or the *Concern* component (20% and 53%; OR = 4.40; 95% CI, 2.94 to 6.58) or the *Conspiracy* component (26% and 53%; OR = 3.02; 95% CI, 2.03 to 4.50) (Table 4).

Vaccine literacy and general health literacy

Compared to staff members, people living in prison had lower levels of both vaccine literacy and general health literacy (both p-values < 0.001). In both groups, vaccine literacy was heterogeneous by country (p-values = 0.02 and < 0.001 in people living in prison and staff, respectively); among people living in prison, it increased with age (p-

Table 4
Association between the subscales of vaccine hesitancy and previous vaccine refusal.

		"Did you ever refused to receive a vaccination?"		OR	(95% CI)	*p-value**
		No	Yes			
		N (%)	N (%)			
Mistrust	Q1	260 (74.9)	87 (25.1)	1.00		*<0.001*
	Q2	224 (66.3)	114 (33.7)	1.48	(1.01 to 2.18)	
	Q3	227 (67.2)	111 (32.8)	1.88	(1.27 to 2.79)	
	Q4	112 (35.0)	208 (65.0)	6.50	(4.32 to 9.78)	
Concern	Q1	289 (80.3)	71 (19.7)	1.00		*<0.001*
	Q2	216 (66.1)	111 (33.9)	2.11	(1.41 to 3.17)	
	Q3	165 (50.5)	162 (49.5)	3.95	(2.64 to 5.91)	
	Q4	153 (46.5)	176 (53.5)	4.40	(2.94 to 6.58)	
Conspiracy	Q1	247 (74.0)	87 (26.0)	1.00		*<0.001*
	Q2	225 (68.0)	106 (32.0)	1.35	(0.91 to 2.00)	
	Q3	186 (57.1)	140 (42.9)	1.87	(1.26 to 2.78)	
	Q4	165 (46.9)	187 (53.1)	3.02	(2.03 to 4.50)	

*The p-value refers to the test for linear trend.

value < 0.001); among staff, it was lower in men (p-value = 0.05) and in less educated subjects (p-value < 0.001) (Supplementary Table 3). In both people living in prison and staff, general health literacy was heterogeneous by country (p-values = 0.006 and < 0.001 in people living in prison and staff, respectively) and was lower in less educated people (p-values < 0.001); among people living in prison, the lowest levels were observed among migrants (p-value = 0.004) (Supplementary Table 4).

Association between the vaccine hesitancy and literacy

Vaccine hesitancy was inversely correlated with vaccine literacy in both people living in prison (Pearson correlation coefficient = -0.12; p-value = 0.002) and staff (Pearson correlation coefficient = -0.35; p-value < 0.001).

The estimated marginal means from the linear models of each vaccine hesitancy scale by quartile of vaccine and general health literacy are reported in Table 5. Both *Mistrust* and *Concern* decreased with vaccine literacy increasing or general health literacy increasing. *Conspiracy* did not show any statistically significant trend with vaccine literacy, but significantly decreased with general health literacy.

Sensitivity analysis

The careless analysis of the vaccine literacy questions identified 442 (28%) participants providing unreliable responses. The larger proportion of carelessness was from Cyprus; among the participants' characteristics the only statistically significant association was observed with level of education (Supplementary Table 5). When careless responders were excluded from the analysis, no material difference was observed in the exploratory factor analysis (results not shown); in the association between factors and participants' characteristics (Supplementary Table 6); in the association between factors and reported history of refusal to be vaccinated (Supplementary Table 7); in the association between factors and vaccine literacy or general health literacy (Supplementary Table 8).

Discussion

We observed an inverse association between vaccine hesitancy and vaccine and general health literacy in a sample of people living in prison and staff. The scale used to assess vaccine hesitancy presented an underlying structure with three dimensions: *Mistrust*, reflecting a general lack of confidence in vaccines and doctors; *Concern*, reflecting the perception of the possible negative consequences of vaccines; *Conspiracy*, correlated to the fear of misbehaviour from the institutions. All three dimensions presented good internal consistency and were valid instruments to capture vaccine hesitancy, according to self-reported past behaviour in vaccination programs. *Mistrust* and *Concern* subscales were negatively associated with vaccine literacy and general health literacy, with higher levels of hesitancy in those presenting lower levels of literacy.

The vaccine hesitancy scale, a modified version of a scale developed to capture vaccine hesitancy in parents regarding vaccination of their children, allowed to identify three independent subscales; the first two subscales were consistent with those previously identified by Shapiro *et al.* [13]. Shapiro *et al.* used exploratory factor analysis to identify two factors, named *Lack of Confidence* and *Risk*. Subsequently, each item of the vaccine hesitancy scale was assigned to the factor with which it exhibited a higher correlation and subscalescores were calculated from the original items. On the contrary, we used factor analysis to identify three factors and quantified vaccine hesitancy associated to each of them by extracting the factor scores. With this procedure, we were able to retain the information captured by all the items in the scale, even those highly correlated. The resulting subscales were independent and proved to be a valid construct of vaccine hesitancy.

Previous attempts to quantify vaccine hesitancy in prison were conducted mainly in relation to the COVID-19 pandemic [16–19]. A large cross-sectional study conducted in a rural Midwest US male prison assessed vaccine hesitancy in 610 inmates and 149 staff members using the scale by Shapiro *et al.* on a four-points Likert scale [19]; the mean levels of vaccine hesitancy in the *Lack of Confidence* and *Risk* components were similar to the values calculated in our sample using the same items used by Shapiro *et al.* opportunely rescaled. It is worth to mention that similarly to our finding, the lower level of confidence in vaccine, doctors and institutions in the US prison sample was reported among

Table 5
Association of the subscales of vaccine hesitancy with vaccine and general health literacy.

	Mistrust		*Concern*		*Conspiracy*	
	EMM (SE)	*p-value**	EMM (SE)	*p-value**	EMM (SE)	*p-value**
Quartiles of vaccine literacy		*<0.001*		*<0.001*		*0.228*
Q1	0.28 (0.05)		0.21 (0.05)		0.11 (0.04)	
Q2	0.10 (0.05)		0.06 (0.04)		0.15 (0.04)	
Q3	−0.09 (0.05)		−0.03 (0.05)		0.09 (0.05)	
Q4	−0.14 (0.07)		−0.29 (0.07)		0.02 (0.06)	
Quartiles of general health literacy		*<0.001*		*<0.001*		*<0.001*
Q1	0.12 (0.04)		0.37 (0.04)		0.13 (0.04)	
Q2	0.13 (0.04)		0.08 (0.04)		−0.01 (0.04)	
Q3	−0.02 (0.05)		−0.01 (0.05)		0.08 (0.04)	
Q4	−0.35 (0.05)		−0.64 (0.04)		−0.19 (0.04)	

Estimates are from linear models adjusted for country, group (staff, non-migrant people living in prison, migrant people living in prison).
*the p-value refers to the test for linear trend.

individuals with the higher degree of education. However, given the different composition of the two samples, it is hard trying to compare the observed associations with socio-demographic factors in the two studies. A randomized clinical trial conducted in four Canadian prisons reported that those randomized to receive an intervention tailored to addressing COVID-19 vaccine hesitancy in term of risk perception, lack of knowledge, lack of trust and perceived lack of benefits had a high COVID-19 vaccine uptake compared to controls [16]; also, education increased confidence among people living in prison, with significant improvements in knowledge and more favourable attitudes and beliefs towards COVID-19 vaccines. The results of this randomized trial go in the same direction as our finding of an inverse association between vaccine hesitancy and vaccine literacy and reinforce the hypothesis that a program aimed at increasing vaccine literacy can potentially increase vaccine uptake also in our population.

One of the main strengths of our study is its multicentre design, able to capture vaccine hesitancy across a variety of cultural backgrounds, due to the involvement of prisons in different European countries and to the presence of migrants among people living in prison. The large size of the study sample is the result of the joint effort of all partners, health officers and prison administration staff. The largest participation was from Moldova, contributing participants from seven of the seventeen prisons in its national territory, corresponding approximately to the ten percent of the country's people living in prison and twenty percent of the country's prison staff (European Organisation of Prison and Correctional Services (EUROPRIS) [20]). To overcome the structural difficulties of conducting a survey in prison setting, where the population is made of vulnerable individuals, heterogeneous for language, cultural background and socio-economic background, each detection centre adopted an opportunistic sampling procedure, that resulted in a study group oversample for higher level of education, lower age and male component. In order to minimize the effect of this selection bias, we adjusted all analyses for a variety of sociodemographic characteristics of participants. Moreover, because the main aim of the survey was to assess the association between vaccine hesitancy and vaccine literacy, it is unlikely that we obtained biased results due to lack of representativeness of the sample. The vulnerability of the individuals posed constraints in the way they were approached and increased the risk of response bias due to the willingness of participants to provide answers that are socially acceptable. The sensitivity analyses conducted by excluding unreliable responses indicate that careless is unlikely a source of bias in our data.

Among the limitations of our study, there is the possible reduced external validity of our finding, due to the limited number of countries involved and the fact that the 3 French prisons are all in South of the country, and the 2 Italian prisons are both in the North of the country. Another limitation is the fact that questionnaires could be either self-administered or administered through an interviewer; this is a possible cause of the observed heterogeneity between countries and groups. Finally, our study investigated the impact of literacy on vaccine hesitancy, without considering other factors that could trigger motivation to get vaccinated [21]. It has been shown that in some settings, multicomponent interventions can be more effective to increase vaccine uptake than education only [22] and further investigations should be planned to assess the role of these other components.

Our results indicate the existence of an inverse association between vaccine literacy and vaccine hesitancy, suggesting that the implementation of educational programs addressed to increase vaccine literacy among prison population and staff can potentially trigger a positive attitude toward vaccination offer. The challenge is now to develop and implement a proper educational program able to decrease the level of vaccine hesitancy among people living or working in prison and quantify its effect on vaccination uptake.

CRediT authorship contribution statement

D. Petri: Writing – review & editing, Writing – original draft, Validation, Software, Investigation, Data curation. **M. Fornili:** Writing – review & editing, Writing – original draft, Validation, Formal analysis, Data curation. **E. De Vita:** Writing – review & editing, Investigation, Data curation. **M.A. Malanima:** Writing – review & editing, Investigation, Data curation. **I. Yiasemi:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **J. Mavrou:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **T. Trattonikolas:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **I. Stylianou:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **F. Meroueh:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **E. Murauer:** Writing – review & editing, Resources, Investigation, Conceptualization. **A. Mieuset:** Writing – review & editing, Resources, Investigation, Conceptualization. **R. Ranieri:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **N. Cocco:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **V. Busmachiu:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **I. Barbirosh:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization. **L. Tataru:** Writing – review & editing, Supervision, Investigation. **S. Doltu:** Writing – review & editing, Supervision, Investigation, Conceptualization. **S. Mazzilli:** Writing – review & editing, Investigation, Conceptualization. **L. Tavoschi:** Writing – review & editing, Supervision, Resources, Funding acquisition, Conceptualization. **L. Baglietto:** Writing – original draft, Supervision, Resources, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jvacx.2024.100537.

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