Factors associated with non-pharmaceutical interventions compliance during COVID-19 pandemic: a Portuguese cross-sectional survey

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ABSTRACT

Background The use of non-pharmaceutical interventions (NPI) is one of the main tools used in the coronavirus disease 2019 (COVID-19) pandemic response, including physical distancing, frequent hand washing, face mask use, respiratory hygiene and use of contact tracing apps. Literature on compliance with NPI during the COVID-19 pandemic is limited.

Methods We studied this compliance and associated factors in Portugal, between 28th October 2020 and 11th January 2021 (Portuguese second and third waves of the pandemic), using logistic regressions. Data were collected through a web-based survey and included questions regarding NPI compliance, COVID-19-related concerns, perception of institutions' performance, agreement with the measures implemented and socio-demographic characteristics.

Results From the 1263 eligible responses, we found high levels of compliance among all COVID-19 related NPI, except for the contact tracing app. Females and older participants showed the highest compliance levels, whereas the opposite was observed for previously infected participants. There was heterogeneity of COVID-19 NPI compliance across Portuguese regions and a clear gradient between concern, government performance's perception or agreement and compliance.

Conclusions Results suggested areas for further study with important implications for pandemic management and communication, for future preparedness, highlighting other factors to be accounted for when recommending policy measures during public health threats.

Keywords compliance, COVID-19 pandemic, non-pharmaceutical intervention, Portugal, public health

Introduction

The first public health response measures to the coronavirus disease 2019 (COVID-19) pandemic, in the absence of an effective and safe vaccine, were non-pharmaceutical interventions (NPI), which were recommended at all levels including global, European, national, regional and local. Despite the rollout of COVID-19 vaccines and the good preliminary effectiveness results, many countries still remain with NPI. In fact, the uncertainty of vaccine effectiveness in future viral variants highlights the importance of NPI as a complementary method for an effective pandemic response.

According to the European Centre for Disease Prevention and Control, these interventions can be categorized in three main groups: (i) individual, such as hand hygiene, respiratory hygiene and face mask use; (ii) environmental,

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such as ventilation of indoor spaces and (iii) population-related, including physical and social distancing and movement restriction.[1] Different countries implemented distinct approaches and degrees of stringency. In Portugal, since the pandemic was declared (March 2020), most individual NPI were recommended, although face mask use was initially suggested only for some specific groups or contexts.[1,2] Other NPI were applied throughout the pandemic such as the temporary closing of several services or curfews for the general population.

In mid-October, the Portuguese Government recommended the general use of face mask and the use of a distance contact tracing mobile application (Stayaway COVID).[3] A few days later, in 27th October 2020, the mandatory use of face mask was extended from public closed spaces to public open spaces, in situations where social distancing was not possible.[4] Since then, a 'Rule of 5' COVID-19 communication strategy was followed: (i) physical distancing; (ii) frequent hand washing; (iii) mandatory use of face mask; (iv) respiratory hygiene and (v) use of the distance contact tracing app.

There is an increasing body of literature, including in European countries, analyzing NPI compliance and its associated factors, such as gender or age.[5–30] However, most of these studies have taken place in the first months of the pandemic or focused specific NPI such as social distancing. Moreover, only a few were conducted in Southern Europe and only one in Portugal, with this latter not including a full model of NPI associated factors.[17,19–24,27,28] Thus, this study is paramount as it has become clearer that NPI associated factors can be context-specific both in time and place.[9,17,19] Studying citizens' behaviors is an essential step in order to have effective and potentially tailored communication plans or measures, with no single 'one-size-fits-all' approach.

In this paper, we studied the socio-demographic and individual beliefs' factors associated to compliance with NPI during the second and beginning of the third waves of the COVID-19 pandemic in Portugal, but also to documented concern, agreement with measures, and perception of the Portuguese government's performance as mediators of NPI compliance.

Methods

Survey design

This survey presents the fourth wave of a previously distributed survey focusing on the description of attitudes and practices of the Portuguese population towards the COVID-19 pandemic.[31]

In this wave, specific questions for NPI compliance were added, as well as potential associated factors, following the Health Belief Model.[32,33]

The Health Belief Model helps us deal with compliance to treatments and health measures. This model suggests that patients are more likely to comply with health recommendations when they feel susceptibility to illness, believe the illness to have potential serious consequences for health or daily functioning, feel benefits on health and do not anticipate major obstacles, such as side effects or costs.[34,35] For this reason, patients must predict that by following a set of health recommendations, which in this particular case are related with NPI, the threat or severity of the condition will be abolished or reduced.

Before each wave, pilot surveys were conducted to calibrate questions, validate proper understanding and ensure the adequacy of survey length.

Sampling and data collection

We performed and distributed an online survey through social networks (WhatsApp, Facebook, Twitter and email), professional boards, hospitals and patient associations, asking them to disseminate the survey amongst their associates. Answers were collected from Portuguese residents between 28th October 2020 and 11th January 2021.

Collected measures

The main outcome measures collected comprised the NPI of the Portuguese 'Rule of 5' on COVID-19 prevention: (i) physical/social distancing (PD); (ii) hand washing (HW); (iii) face mask use (FM); (iv) respiratory hygiene (RH) and (v) use of the distance contact tracing app (CTA). Participants were asked to rate their compliance level with the following options: 1 = 'never'; 2 = 'rarely'; 3 = 'often'; 4 = 'always' or 'do not know/prefer not to answer'. This 'Rule of 5' was widely diffused by the government, health institutions and social media and these questions were closely aligned with it both in content and wording.

Participants were asked if they were previously infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection or if they knew anyone who had had COVID-19 disease. We also asked the levels of concern with the possibility of being infected.

Levels of agreement with several measures, including two of the aforementioned 'Rule of 5', were assessed with the following options: 1 = 'fully disagree'; 2 = 'partially disagree'; 3 = 'do not disagree nor agree'; 4 = 'partially agree' or 5 = 'fully agree'.

Perception of the Portuguese government's performance was assessed, with respondents being asked to describe it as very bad/bad/fair/good/very good.

The survey included questions on socio-demographic characteristics, such as age, gender, residence, education, income, occupation and household composition.

Data analysis

For this study, we only considered responses with >98% of the survey completed. The analysis includes a section of descriptive statistics, followed by a set of logistic regressions to estimate the association between factors and NPI compliance, which was dichotomized in 1/2 ('never' or 'rarely') and 3/4 ('often' or 'always'). We applied several models, including different dimensions in each model, as further described below.

We defined the variables to be included in the models, by checking correlations between collected variables. For robustness checks, and for these models, we obtained similar results (with no statistically significant differences for new variables or significant changes in the models) with the following analyses: (i) logistic regressions including average number of COVID-19 cases in the last 7 days and the effective reproduction number (analyzed using both daily and weekly approaches); (ii) ordered logistic regressions and (iii) seemingly unrelated regressions combining four out of five outcomes (physical/social distancing, hand washing, face mask use and respiratory hygiene).

Results

Between 28th October 2020 and 11th January 2021, a total of 1263 eligible responses were registered.

Hand washing (HW) showed the highest compliance level with 97.7% reporting doing it 'often' or 'always', followed by respiratory hygiene (RH) with 97.6%, physical/social distancing (PD) with 95.5%, use of face mask (FM) with 95.0% and, with a large distance, contact tracing app use (CTA) with 30.5%. Figure 1 displays the participants' compliance per outcome (A), as well as by gender (B), age group (C), region (D), concern with being infected (E), perception of the Portuguese government's performance (F) and agreement with measures (G), respectively.

Table 1 displays the sample descriptive statistics, as well as the average marginal effects for the different models using logistic regression by NPI compliance outcome (M1—including only socio-demographic factors; M2 – M1 including previous SARS-CoV-2 infection or knowing someone with COVID-19; M3 – M2 including general concern of being

infected; M4 – M3 including perspectives of the Portuguese government's performance and M5 – M3 including agreement with the measure). In Model 5, only FM and CTA were included as agreement was assessed only for those NPI.

In Models 1 and 2, male individuals were associated with a statistically significant 3–10 pp (percentage points) lower compliance levels. For these models, North region participants showed a statistically significant increase for FM, PD and CTA, relative to the Lisbon region, whereas FM compliance remained statistically significant in all models (ranging from 3 to 12 pp). The oldest group ($N = 33$) were totally compliant with all outcomes but CTA.

When considering to the lowest monthly income category ($< 1000€$) as reference, the midpoint category was the only one showing a higher FM compliance. CTA compliance was the only one with statistically significant differences from the baseline, increasing with income in all models. Participants who were previously infected ($N = 33$) were all non-compliant with FM and HW, whereas participants who knew someone who had had COVID-19 showed lower compliance with PD. Households with health professionals showed a higher statistically significant compliance with FM and PD by >3 pp.

Considering participants' concerns, there was a clear gradient between the general concern with being infected and being compliant (Model 3). There was also a clear positive gradient with perception of the Portuguese government's performance (Model 4). When including agreement with FM or CTA, there was a gradient mainly for CTA agreement. In fact, those that fully disagree with FM showed a statistically significant 24 pp lower compliance than those who do not disagree nor agree. This value was of 17 pp for CTA while those who fully agree showed 57 pp higher compliance.

Discussion

Main findings of this study

In this study, we documented the NPI compliance for a Portuguese sample during the second wave and beginning of the third of the COVID-19 pandemic (end October 2020–January 2021). We found high compliance levels (higher than 95%) for hand washing, respiratory hygiene, physical/social distancing and facemask use. However, less than a third was compliant with the use of the contact tracing app. We also showed that female individuals had higher compliance with NPI measures and the oldest group (65 years old or more) had total compliance with all NPI, except for CTA use. We did not find a clear association between education and employment with NPI compliance.

Fig. 1 Frequencies of compliance with the NPI during COVID-19 pandemic, in Portugal in the end 2020 for: A—total; B—gender; C—age group; D—region; E—concern of being infected; F—perception of the Portuguese government's performance; G—agreement with measures.

Table 1 Descriptive statistics and average margin effects of logistic regression of COVID-19 NPIs' compliance, in Portugal in the end 2020, by model and outcome

	N (%)	Model 1					Model 2					Model 3					Model 4					Model 5	
		FM	PD	RH	HW	CTA	FM	PD	RH	HW	CTA	FM	PD	RH	HW	CTA	FM	PD	RH	HW	CTA	FM	CTA
Age																							
< 18 years	19 (1.51)	−0.0500	−0.141	−0.189	−0.0207	−0.0954	−0.0556	−0.194	−0.183	−0.0312	−0.0954	−0.0582	−0.269	−0.208	−0.0949	−0.136	0.0326	−0.185	−0.287	−0.0457	−0.0272	0.0485**	0.0552
18–25 years	227 (17.99)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
26–32 years	284 (22.50)	0.0285	0.0428	0.0415	0.0115	0.0315	0.0292	0.0436	0.0396	0.0117	0.0318	0.0403	0.0368	0.0386	0.0114	0.0328	0.0790*	0.0204	0.0356	0.0107	0.00433	0.00256	0.0178
33–45 years	402 (31.85)	−0.00119	0.0303	0.0344	0.0123	−0.0262	−0.00193	0.0274	0.0325	0.0134	−0.0312	0.0184	0.0346	0.0314	0.0139	−0.0289	0.0540	0.0243	0.0308	0.0118	−0.0343	0.0130	−0.0399
46–64 years	296 (23.45)	0.0260	0.0259	0.0424	0.0314	−0.0197	0.0303	0.0257	0.0426	0.0327	−0.0228	0.0341	0.0179	0.0417	0.0333	−0.0223	0.0683	−0.00384	0.0371	0.0304	−0.0430	0.0111	−0.0345
> 64 years	34 (2.69)	c	c	c	c	0.248	c	c	c	c	0.235	c	c	c	c	0.233	c	c	c	c	0.192	c	0.210
Gender																							
Female	740 (59.62)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Male	508 (40.38)	−0.0595***	−0.0601***	−0.0348***	−0.0207	−0.0994***	−0.0621***	−0.0663***	−0.0347***	−0.0392**	−0.0994***	−0.0179	−0.0293*	−0.0249*	−0.0235*	−0.0794*	0.00542	−0.00896	−0.0178	−0.00968	−0.0184	0.0157	−0.00445
Region of residence																							
North	630 (50.56)	0.0568***	0.0396***	0.000262	0.000831	0.0731**	0.0606***	0.0404**	−0.000908	0.000767	0.0754**	0.0476***	0.0322**	−0.00674	−0.00392	0.0549	0.0596***	0.0280*	−0.0115	−0.00553	0.0539	0.0267**	0.0268
Centre	142 (11.40)	0.0416*	−0.0102	0.0229**	−0.00654	0.0508	0.0433*	−0.0215	0.0214*	−0.00858	0.0505	0.0529***	−0.0141	0.0205**	−0.00697	0.0403	0.0737***	−0.00725	0.0203**	−0.0116	0.0405	0.0451***	0.0638
Lisbon	416 (33.39)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Alentejo	40 (3.21)	0.0358	0.00157	−0.0663	−0.0203	0.0450	0.0401	−0.00186	−0.0609	−0.0248	0.0483	0.0539*	−0.0171	−0.0760	−0.0207	0.0492	0.0659*	−0.0154	−0.0676	−0.0115	0.0572	0.0443*	0.0842
Algarve	18 (1.44)	−0.0726	c	−0.0557	c	0.0736	−0.0759	c	−0.0575	c	0.0717	−0.0816	c	−0.0526	c	0.0759	−0.0868	c	−0.0520	c	0.0792	−0.186**	0.0560
Number of persons in household																							
1	81 (6.42)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
2	329 (26.07)	0.00791	−0.0163	0.0140	0.0139	−0.0179	0.00654	−0.0243	0.0137	0.0132	−0.0144	0.0467	−0.00706	0.0197	0.0194	−0.00951	0.0457	−0.00376	0.0183	0.0167	−0.0234	0.0521*	0.0247
3	383 (30.35)	0.0185	−0.0168	−3.99e-05	0.00296	−0.0235	0.0194	−0.0219	0.00130	0.000690	−0.0173	0.0511	−0.0137	0.00375	0.00418	−0.0238	0.0549	−0.0115	0.00267	−0.00393	−0.0388	0.0504*	0.00290
4	322 (25.52)	−0.000318	−0.00464	0.0103	0.0283	−0.0559	−0.00113	−0.00846	0.0113	0.0276	−0.0501	0.0413	0.00428	0.0171	0.0341	−0.0459	0.0360	0.00786	0.0132	0.0303	−0.0526	0.0420	0.00248
5	105 (8.32)	0.0306	0.0316	−0.0138	0.0131	0.104	0.0313	0.0280	−0.0151	0.0120	0.109	0.0603	0.0383	−0.0160	0.00937	0.103	0.0794*	0.0437	−0.0139	0.0156	0.0725	0.0797***	0.116
> 5	42 (3.33)	−0.0554	−0.0806	−0.0398	−0.0495	−0.0669	−0.0337	−0.0573	−0.0398	−0.0470	−0.0509	0.0416	−0.00964	−0.00183	−0.0165	−0.0509	0.0457	0.00403	−0.00156	−0.000920	−0.00248	0.0656**	0.0407
Household with > 65 years member	252 (19.95)	−0.0100	−0.0143	−0.00662	−0.00519	−0.0679*	−0.0168	−0.0187	−0.0105	−0.00572	−0.0718*	−0.0235	−0.0250	−0.0119	−0.0119	−0.0718*	−0.0258	−0.0315	−0.00868	−0.0127	−0.0709*	−0.0418**	−0.0623*
Household with health professional	240 (19.02)	0.0320**	0.0380***	0.0144	0.0210*	−0.00528	0.0351**	0.0419***	0.0140	0.0216*	−0.00540	0.0402***	0.0444***	0.0161	0.0219*	−0.00912	0.0546***	0.0469***	0.0176	0.0256**	−0.00822	0.0370***	−0.0201
Education attainment level (ISCED)																							
Levels 0, 1 or 2	35 (2.78)	−0.128	−0.0332	−0.146	−0.114	−0.116	−0.135	−0.0277	−0.154	−0.110	−0.122	−0.296**	−0.0802	−0.257	−0.196	−0.133	−0.337***	−0.0687	−0.263	−0.150	−0.125	−0.336***	−0.0580
Level 3	229 (18.20)	0.0315**	0.0222	0.00348	0.00748	−0.0533	0.0316**	0.0189	0.00296	0.00705	−0.0506	0.0218	0.0100	−0.00443	0.00296	−0.0573	0.0364**	0.00565	−0.00600	0.00279	−0.0635	0.0226	−0.0167
Levels 4, 5, 6 and 7	930 (73.93)	(ref)	(ref)	(ref)	c	(ref)	(ref)	(ref)	(ref)	c	(ref)	(ref)	(ref)	(ref)	c	(ref)	(ref)	(ref)	(ref)	c	(ref)	(ref)	(ref)
Level 8	64 (5.09)	0.0102	0.0276	−0.0548	c	−0.0307	0.0233	0.0413**	−0.0433	c	−0.0243	0.0152	0.0346*	−0.0446	c	−0.0248	0.0123	0.0338*	−0.0364	c	−0.0246	0.0122	−0.00672
Monthly income																							
< 1100€	144 (12.63)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
1101–1500€	188 (16.49)	0.0384	0.0255	0.00563	−0.00641	0.0617	0.0412	0.0306	0.00509	−0.00454	0.0626	0.00479	0.0156	−0.00232	−0.0101	0.0647	−0.00567	0.0195	−0.00654	−0.0121	0.0492	−0.0312	0.0493
1501–2000€	249 (21.84)	0.0699**	0.0281	−0.0228	0.00445	0.138***	0.0737***	0.0343	−0.0227	0.00454	0.139***	0.0488**	0.0262	−0.0286	0.000237	0.144***	0.0602**	0.0277	−0.0307	0.00126	0.137***	0.0293**	0.0964**
2001–5000€	461 (40.44)	0.0336	0.0465	0.0119	0.0102	0.146***	0.0343	0.0536	0.0116	0.0107	0.143***	0.000306	0.0365	0.00568	0.00719	0.151***	−0.00724	0.0367	0.00315	0.00730	0.148***	−0.0269*	0.117***
> 5001€	98 (8.60)	−0.000234	−0.00344	−0.00430	0.00127	0.200***	0.00252	0.00565	0.000823	0.00156	0.205***	0.0115	0.0244	−8.43e-06	0.000133	0.229***	0.0180	0.0291	−0.00506	−0.00126	0.217***	−0.00194	0.169***
Occupation																							
Unemployed	69 (5.55)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Student	160 (12.87)	0.163*	0.109	0.0427	0.0382	0.00623	0.182**	0.124	0.0432	0.0413	0.00214	0.196**	0.125*	0.0295	0.0448	0.0536	0.223***	0.0895	0.0114	0.0282	−0.0358	0.133*	−0.0112
Public servant	194 (15.61)	0.147*	0.0667	0.0344	0.0478	−0.0576	0.164*	0.0811	0.0338	0.0516	−0.0621	0.148*	0.0688	0.0113	0.0443	−0.0273	0.117	0.0362	−0.00900	0.0215	−0.0965	0.129*	−0.0132
Retired	46 (3.70)	0.110	0.0652	0.0267	−0.00950	0.0508	0.115	0.0441	0.0209	−0.0156	0.0725	0.113	0.0274	−0.0184	−0.0509	0.131	0.122	0.000124	−0.00516	−0.0665	0.0319	0.116	−0.113
Large enterprise employee	240 (19.31)	0.144*	0.0968	0.0358	0.0412	−0.00159	0.163*	0.110	0.0367	0.0438	−0.00228	0.165**	0.105	0.0199	0.0409	0.0362	0.178**	0.0741	0.0360	0.0247	−0.0176	0.134**	0.0199

(Continued)

Table 1 Continued

	N (%)	Model 1 FM	Model 1 PD	Model 1 RH	Model 1 HW	Model 1 CTA	Model 2 FM	Model 2 PD	Model 2 RH	Model 2 HW	Model 2 CTA	Model 3 FM	Model 3 PD	Model 3 RH	Model 3 HW	Model 3 CTA	Model 4 FM	Model 4 PD	Model 4 RH	Model 4 HW	Model 4 CTA	Model 5 FM	Model 5 PD	Model 5 RH	Model 5 HW	Model 5 CTA
SME employee	282 (22.69)	0.134	0.0846	0.0155	0.0467	−0.0827	0.151*	0.0972	0.0158	0.0493	−0.0816	0.156**	0.0893	−0.00433	0.0446	−0.0390	0.175**	0.0652	−0.0189	0.0365	−0.0853	0.143**				−0.0432
Self-employed	210 (16.89)	0.148*	0.0909	0.0437	0.0326	−0.106	0.165*	0.0993	0.0423	0.0329	−0.108	0.173**	0.102	0.0268	0.337	−0.0632	0.198**	0.0834	0.0129	0.0291	−0.0928	0.151**				−0.0560
Other	42 (3.38)	0.160*	0.106	0.00947	c	0.0766	c	c	0.0253	c	0.0778	c	c	0.00636	c	0.129	c		−0.0143		0.0778	c				0.0924
Economic sector																										
Primary	9 (0.81)	0.980	0.235	−0.0854	−0.438	1.471*	c	c	c	c	0.0595	c	c	c	c	−0.00204	c	c	c	c	−0.0268	c				−0.0110
Secondary	98 (8.84)	−0.290	0.190	0.187	0.0924	0.211	−0.0272	−0.0267	−0.00366	−0.00610	−0.00605	−0.0430*	−0.0152	0.00332	−0.00419	−0.00291	−0.0574*	−0.00255	0.00906	−0.000532	−0.00672	−0.0494**				−0.00776
Tertiary	899 (81.14)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	c	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)				(ref)
Other	102 (9.21)	−0.0269	0.428*	0.672*	0.0957	−0.0367	0.0217	0.00682	0.00983	c	0.0341	0.0153	0.00487	0.0122	c	0.0312	0.0167	0.00491	0.0108	c	0.0124	0.0106				0.00792
Previously infected (SARS-CoV-2)																										
No	1221 (97.37)						(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)				(ref)
Yes	33 (2.63)						Nc	−0.00178	−0.0207	Nc	−0.122	Nc	0.0446	−0.0111	Nc	−0.122*	Nc	0.0217	−0.00311	Nc	−0.112	Nc				−0.0997
Know someone who had COVID-19																										
No	219 (17.42)						(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)				(ref)
Yes	1038 (82.58)						−0.0151	−0.0358**	−0.00424	−0.00765	0.00603	−0.0118	−0.0366***	−0.00566	−0.0120	−0.0125	−0.00878	−0.0360***	−0.00580	−0.0111	−0.0294	−0.00338				0.0123
Concern with being infected																										
1—Null	19 (1.51)											−0.491***	−0.501***	−0.0350	−0.0184	−0.146*	−0.541***	−0.456***	−0.0267	−0.00299	−0.0933	−0.211**				−0.0369
2—Reduced	174 (13.83)											−0.138***	−0.0806***	−0.0516**	−0.0524**	−0.0647	−0.139**	−0.0653**	−0.0431*	−0.0346	−0.0409	−0.0634***				−0.0455
3—Moderate	428 (34.02)											(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)				(ref)
4—High	389 (30.92)											0.0150	0.0215	0.00864	0.0179	0.120***	0.0165	0.0143	0.00948	0.0154	0.105***	0.0211*				0.0348
5—Very high	248 (19.71)											0.0243***	0.0332**	0.202*	0.0273**	0.105**	0.0297***	0.0307**	0.0196*	0.0281**	0.0850**	0.0335***				0.0158
Perception of Portuguese government's performance																										
1—Very bad	232 (18.63)																−0.0533***	−0.0751***	−0.0394**	−0.0598***	−0.194***					
2—Bad	314 (25.22)																−0.0558***	−0.0229	−0.00320	−0.0231*	−0.0160					
3—Fair	425 (34.14)																(ref)	(ref)	(ref)	(ref)	(ref)					
4—Good	228 (18.31)																c	0.00975	−0.0159	−0.00693	0.138***					
5—Very good	46 (3.69)																c	c	c	c	0.208**					
Agreement with measure (mask | app)																										
1—Fully disagree	73 (5.81) | 628 (51.08)																					−0.238***				−0.172***
2—Partially disagree	101 (8.04) | 192 (15.37)																					−0.0779**				−0.0664
3—Do not disagree nor agree	44 (3.50) | 177 (14.17)																					(ref)				(ref)
4—Partially agree	252 (20.06) | 150 (12.01)																					0.0188				0.402***
5—Fully agree	786 (62.58) | 92 (7.37)																					0.0109				0.569***
Total observations	1263	956	951	921	796	966	887	910	917	768	961	884	907	914	765	958	685	870	877	733	950	879				952

Note: c = all compliant ('often' or 'always'); Nc = all non-compliant ('rarely' or 'never').

***$P < 0.01$.

**$P < 0.05$.

*$P < 0.1$ (all statistically significant results are at bold; significance set at 0.05).

On geographical disparities, the North region had higher levels of compliance compared with the Lisbon region. Although this can be related with the higher COVID-19 incidence during November in the North region, when hospital pressure increased, it is interesting to see that even when considering general concern of being infected this can only partially explain these differences.

It is worth noting that all the participants who had previously been infected with SARS-CoV-2 ($N = 33$) reported no compliance with facemask use and handwashing, although we cannot prove that there were actual behavioral changes due to the infection. We have also described a clear gradient between concern with being infected and NPI compliance. In addition, we found a gradient in the association between NPI compliance and the perception of the Portuguese government's performance. For CTA and facemask use, we also identified that the agreement with this measures was associated with the compliance.

What is already known on this topic

Our results of NPI compliance levels were quite in line with those reported in Portugal in April 2020, regarding compliance with hand washing, respiratory hygiene and physical distancing, Portugal being the country with the highest level of adherence within the seven European countries included in the previous study.[19] Nevertheless, in March and April 2020, high levels of compliance with hand washing, respiratory hygiene and physical/social distancing have been reported internationally, with quite lower levels for facemask use.[6,12,35–39] However, other studies showed considerably lower levels of compliance to NPI measures such as social distancing (North London, May 2020)[7] or physical/social distancing and hand washing (UK, April 2020).[16]

In spite of at least one study reporting no differences in the likelihood of preventive behaviors with socio-demographic factors,[35] most studies in the literature related preventive behaviors to sex and age.[5,6,9–11,20,22,25,38–41] In fact, previous studies have reported that the female higher compliance might be related to more active engagement with health information, as well as lower levels of risk tolerance or risk behaviours.[6]

Regarding the lack of NPI compliance among those previously infected, this can be particularly important for policy measures, as immunity duration is still being studied and, despite rare, reinfections were already documented.[42] Smith *et al.* reported that, in the UK (early May 2020), those who thought they had had COVID-19, were less adherent to lockdown measures.[7] A similar behavior was found for tuberculosis, where infected patients became nonadherent to therapeutics and NPI if they 'felt cured'.[43]

The gradient we found between concern and NPI compliance is aligned with other studies showing an association of preventive behaviors with perceived severity, concern regarding COVID-19, trust in others' behavior, among others.[5,9–12,26,36,41] This perspective presents a rational adherent behavior and is aligned with the aforementioned Health Belief Model that introduces 'subjective' variables such as 'perceived severity' of disease, perceived 'susceptibility' or perceived 'barriers' to health and illness behaviour.[44] Also, the retrieved association with trust/confidence in government/authorities is quite consistent in the literature.[5]

Regarding the COVID-19 contact tracing app, although the Portuguese government had proposed in mid-October that its use could become mandatory, this decision did not go ahead. In our sample, only 30.5% showed to be compliant with its use. This is quite low compared with the intention of installing or keeping such an app, even among European countries.[14] There are still concerns regarding CTA use and also operationalization difficulties as it does not allow for a clear risk stratification. Kaspar showed that, among German-speaking participants, the use of such apps depends on its higher efficacy, trust in providers or severity/vulnerability to data misuse.[8] According to previous studies, we also found an association between income and CTA use, as well as between CTA use and government performance/trust.[13,14] Even if using a CTA method with high effectiveness there will still be non-compliers, and monetary incentives may improve compliance when information and arguments fail.[13]

For CTA compliance we found a clear gradient of association between agreement with the measure and its compliance. For facemask use a similar pattern was found, with those who disagreed showing lower levels of compliance. In fact, Hills and Eraso have described a similar pattern in Northern London.[7] This information can be essential for pandemic management and communication.

In addition, despite other studies having reported association of NPI compliance with education and employment,[38] we did not find such gradients in our study. In fact, both factors lack consistency of such effect in the literature.[5]

What this study adds

Specific actions through media and behavioral interventions should be considered to tackle this pandemic and to improve NPI measures compliance (both in altering and maintaining their behavior). Behavioral change or health promotion frameworks (e.g. Behavior Change Wheel, Capability-Opportunity-Motivation-Behavior model, Health Belief Model, Protection Motivation Theory, Theory of Planned Behavior or the Socio-Ecological Model) should be used to achieve this end.[5,32,33,45,46] In fact, several interventions

including communicating the risk of the vulnerable or inducing empathy for them have proven to be effective.[47,48] Moreover, it has been reported that influencing beliefs might be more effective than policy changes.[18]

In fact, according to Coroiu et al. who performed a survey mainly across North America and Europe, some of the most common facilitators of social distancing were 'I want to protect others', 'I want to protect myself', 'I feel a sense of responsibility to protect our community' and 'I want to avoid spreading the virus to others'.[6] Similarly, Carlucci et al. showed similar results in Italy, with the most common facilitators being 'I want to prevent the spread of COVID-19' and 'I don't want to transmit COVID-19 to people close to me'.[21]

In addition, public health authorities should provide and communicate alternatives for safe social engagement with others, using 'non-blaming and non-stigmatizing language' targeting specific groups.[6]

However, besides communication, one of the key strategies that must be considered and can have an impact on the compliance is to improve trust in government and authorities.[5] In fact, one of the most common barriers to social distancing in the study from Coroiu et al. was 'I don't trust the messages my government provides about the pandemic'.[6]

Moreover, we highlighted that NPI associated factors can be context-specific both in time and place.[9,11,12,17,19,29] Several reasons might impact NPI compliance through time, such as lockdown rules[7] or relapsing behaviours,[49] but also factors associated with its compliance.[9] Thus, close and continuous monitoring of health behaviors should be done by the public health authorities.

Based on our results, which we conjecture will be present in further studies on other samples, we propose a set of recommendations including targeting of specific groups, such as younger people, men and those previously infected with SARS-CoV-2. In addition, there are regions where this concern should be higher and trust in government and authorities should be strengthened.

Limitations of this study

This study has some limitations, such as the non-representative sample of the Portuguese population, the small number of responses in specific groups, self-selection (as it was a voluntary web-based survey) and broad questions on compliance (such as for physical/social distancing, with several dimensions not appraised[6,50,51]). In fact, most studies with similar purposes also used convenience sampling methods.[5] No causal association can be inferred and there might be omitted variable bias. Moreover, many other variables could be surveyed, including politics, knowledge about pandemics or belief in conspiracy theories.[5] Despite these limitations our results are valid and can have important policy implications.

Conclusions

In conclusion, we found high levels of compliance in Portugal by the end of 2020, with all COVID-19 related NPI but the contact tracing app. Female gender and older participants were the most compliant, against the previously SARS-CoV-2 infected participants who showed the lowest compliance levels. There was heterogeneity of COVID-19 NPI compliance across Portuguese regions and a clear gradient between concern or agreement and compliance. Our discussion has important implications for pandemic management and communication, for future preparedness and for highlighting other factors to be accounted for when recommending new measures during public health threats.

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Ethical approval

The survey received ethical approval by the Installing Committee of Nova School of Business and Economics' Ethics Commission (Comissão Instaladora do Comité de Ética).

Consent to participate

Before voluntary participation, all participants were informed that their responses would be used only for scientific purposes.

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Conflict of interest

None declared.

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