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Reduction of cardiac imaging tests during the COVID-19 pandemic: The case of Italy. Findings from the IAEA Non-invasive Cardiology Protocol Survey on COVID-19 (INCAPS COVID)

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ABSTRACT

Background: In early 2020, COVID-19 massively hit Italy, earlier and harder than any other European country. This caused a series of strict containment measures, aimed at blocking the spread of the pandemic. Healthcare delivery was also affected when resources were diverted towards care of COVID-19 patients, including intensive care wards.
Aim of the study: The aim is assessing the impact of COVID-19 on cardiac imaging in Italy, compare to the Rest of Europe (RoE) and the World (RoW).
Methods: A global survey was conducted in May–June 2020 worldwide, through a questionnaire distributed online. The survey covered three periods: March and April 2020, and March 2019. Data from 52 Italian centres, a subset of the 909 participating centres from 108 countries, were analyzed.
Results: In Italy, volumes decreased by 67% in March 2020, compared to March 2019, as opposed to a significantly lower decrease ($p < 0.001$) in RoE and RoW (41% and 40%, respectively). A further decrease from March 2020 to April 2020 summed up to 76% for the North, 77% for the Centre and 86% for the South. When compared to the RoE and RoW, this further decrease from March 2020 to April 2020 in Italy was significantly less ($p = 0.005$), most likely reflecting the earlier effects of the containment measures in Italy, taken earlier than anywhere else in the West.
Conclusions: The COVID-19 pandemic massively hit Italy and caused a disruption of healthcare services, including cardiac imaging studies. This raises concern about the medium- and long-term consequences for the high number of patients who were denied timely diagnoses and the subsequent lifesaving therapies and procedures.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spread severely in Italy in early 2020, and particularly in its northern regions. The first two cases, both tourists from China, were reported at the end of January and a confirmed first death noted at the end of February. The first medical ethics recommendations regarding triage protocols required to be employed were published by the Italian College of Anaesthesia, Analgesia, Resuscitation and Intensive Care at the beginning of March [1].

Taking an unprecedented decision, and after a series of increasingly stricter measures, on March 11 the whole country was decreed in total lockdown [2], the first country in Europe and Western world, with free circulation not allowed, without written justification, and all activities closed, an exception being made for essential services.

Furthermore, many elective hospital procedures were reduced and/or cancelled at the national level, even if the number of subjects positive to COVID-19 was very different in the three macro-areas of the country. The same type of decision was taken a few days later by other countries in the rest of Europe and worldwide.

To understand the impact of those restrictions on the provision of diagnostic cardiac imaging procedures, the Division of Human Health of the International Atomic Energy Agency (IAEA) launched a worldwide survey - the IAEA Noninvasive Cardiology Protocols Study of COVID-19 (INCAPS COVID). For this cross-sectional study, facilities all around the world were approached, seeking their voluntary contribution to the survey. Initial data on 909 respondents from 108 countries have been already published [3]. Out of those 909 centres, 52 were from Italy.

This aim of this paper is to discuss the variation in volumes of cardiac procedures from March 2019 to March and April 2020 in those 52 centres, analyzing contributions from participants from Italian centres. Their results are also compared to the rest of Europe (RoE) and the Rest of the World (RoW).

2. Methods

A data collection form was designed by an international group of IAEA consultants in clinical cardiology and cardiac imaging and distributed in May and June 2020 through an online platform, designed by the IAEA and named International Research Integration System (IRIS) [4]. The questionnaire was conceived to collect general information about the healthcare facility; availability and use of personal protective equipment (PPE); strategic plans for reopening; changes in

Fig. 1. The breakdown of the three Italian macro-regions. Northern regions are contoured in green, Central regions in white and Southern and Islands in red. Blue dots represents locations of participating centres. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

volume of cardiac procedures performed in March 2020 and April 2020 as compared to March 2019.

For Italy, data were aggregated for the whole country and further subdivided into three regions identified as Northern Italy; Central Italy; and Southern Italy and Islands (Fig. 1). Participating centers were from: Ancona (2); Bari; Bergamo; Bologna (3); Bolzano; Brescia (2); Cefalù (PA); Chieti; Faenza (RA); Ferrara (2); Firenze; Genova; Mantova; Messina; Milano (4); Napoli (3); Novara; Padova; Palermo (2); Pavia; Pisa (3); Reggio Emilia (2); Roma (7); Rovigo; Salerno; Siena; Torino (2); Trento; Treviso; Veruno (NO).

Data were also aggregated for the Rest of Europe (RoE) and the Rest of the World (RoW). The RoE did not include Italy and likewise RoW did not include European countries. European countries were identified following the IAEA/United Nations classification [5].

Participating centres provided their estimated activity volumes data for each modality, as listed in Table 1. To reflect the impact of COVID-19 on cardiac imaging, those estimates were provided for three time-points, starting from March 2019, taken as the pre-COVID control period, then March and April 2020. Surveyed cardiac procedures were: Stress electrocardiogram [ECG]; Stress echocardiography [Echo]; Stress single photon positron emission computed tomography [SPECT]; Stress positron emission tomography [PET]; Stress cardiac magnetic resonance [CMR]; Coronary Artery Calcium Score [CACS]; Coronary Computed Tomography Angiography [CCTA]; Transthoracic echocardiogram [TTE]; Transoesophageal echocardiography [TEE]; PET infection; Invasive coronary angiography (ICA).

Based on data published by the Ministry of Health with the support of Protezione Civile and Istituto Superiore di Sanità [6], the number of COVID-19 tests performed in the three different macro-areas of Italy during the surveyed period, 1st March 2020 through 30th April 2020, and the percentage of infected subjects, was strikingly different: in the North the number of performed test was 1,267,715, with a positivity rate of 12.95%, in the Centre performed tests were 419,834 with a positivity of 6.39% and in the South tests were 291,668 and positivity was 4.95%.

2.1. Statistics

Univariable and multivariable linear regression analyses were performed to evaluate for independent variables associated with procedure volume reduction in Italy. Factors analyzed included inpatient vs. outpatient practice, academic vs. non-academic practice, facility payer mix (private, public, or university), and weighting factors including number of hospital beds and baseline procedure volumes. Percentage reductions were calculated for each test modality, comparing the procedure volume from March 2019 to March and April 2020. The percentage volume reduction of each procedure type performed in Italy over this time period was compared to the reduction seen in RoE and RoW. This comparison was performed for each procedure type and differences in frequency distributions were statistically compared using chi-square and Fisher's exact tests and differences in continuous variables were compared using the Kruskal-Wallis test. When comparing the COVID tests data for the three different areas of Italy, a Z test for two binomial distributions was used.

A p-value < 0.05 is considered statistically significant (two-tailed where appropriate). Statistical analysis was conducted using Stata/IC 16.1 (StataCorp, College Station, TX, USA).

Table 1
Volumes of cardiac imaging procedures for Italy, RoE and RoW [IQR = Interquartile Range].

	Italy	RoE	RoW	p
Number of centres	52	201	655	
Number of procedures				
March 2019	25,579	117,237	535,688	
March 2020	8318	70,759	315,535	
April 2020	5763	38,689	199,953	
Procedures/center, median [IQR]				
March 2019	215 [62–1013]	260 [84–845]	276 [80–850]	0.571
March 2020	70 [15–261]	130 [39–502]	150 [45–550]	**0.004**
April 2020	32 [10–160]	56 [12–368]	70 [14–288]	0.160

Bold values indicate changes are statistically significant.

3. Results

At worldwide level, responses have been received by 909 centres from 108 countries in May and June 2020. To avoid duplicate submissions, when more than one department was involved from the same institution, they were requested to merge the different responses in one single form. Out of the 909 centres, 52 were from Italy, of which 28 from the Northern region, 15 from the Centre and 9 from the South and Islands. The percentage of positive subjects was significantly different in the 3 macroregions during the surveyed period (North vs Central $p < 0.0001$; Central vs South $p < 0.0001$; North vs South $p < 0.0001$).

The volume of procedures performed per centre for the whole country (Table 1), in March 2019, taken as the control period of the pre-pandemic era, did not significantly differ ($p = 0.571$) from RoE and RoW, with median values of 215 for Italy, 260 for RoE and 276 for RoW. However, in March 2020 volumes were reduced significantly ($p = 0.004$) for Italy as compared to RoE and RoW: median values for number of procedures/centre were 70, 130 and 150, respectively. In April 2020, those volumes of activity were further reduced in Italy as well as in the RoE and in the RoW, but differences were no longer statistically significant ($p = 0.160$). The entity of those reductions is also shown in Fig. 2.

Supplementary Table 1 describes Italian and Worldwide variations in procedure volumes by facility characteristic, including practice setting and academic affiliation.

In regards to Italy, a breakdown among the three regions shows that in March 2020 compared to March 2019 the cardiac procedures reduction (Tables 2 and 3) for the North was 65% (median 74 vs 215), almost matching the value for the entire nation; for the Centre, the reduction was 47% (median 120 vs 223) while it was much higher for Southern Italy and Islands (88%, median 20 vs 90), despite a much lower incidence of positive COVID cases. These differences, however, fail to reach statistical significance ($p = 0.114$). Of note, the epidemic in March–April 2020 hit much harder the North than the Centre and South.

As regards reduction in cardiac imaging in private, public and university centres, no significant difference was found, as shown in Supplementary Table 2.

If we consider total volumes across the participating centres in Italy, cardiac imaging procedures in March 2020 as compared to March 2019 were reduced to 8138 from 25,579 (Table 2; Fig. 2). In RoE and RoW, a similar though smaller reduction was seen (70,759 in March 2020 vs 117,237 in March 2019 in RoE and 315,535 vs 535,688 in RoW).

As shown in Table 3, the overall percentage of reduction from March 2019 to March 2020 was rather homogeneous within Italy, but significantly higher for the whole country compared to RoE and RoW (67% vs 41% vs 40%, respectively; $p < 0.001$). However, this statistical significance in difference is lost when we compare March 2019 with April 2020 [$p = 0.164$], reflecting that the further loss of productivity in Italy was significantly lower than in RoE and RoW (10% vs 22% vs 20%, respectively; $p = 0.005$) over the period March 2020–April 2020.

Looking at the surveyed modalities, we see a striking reduction of almost all modalities from March 2019 to March 2020 (Table 4 and Fig. 3). These reductions were greater, and statistically significant, for the country as a whole in comparison to both RoE and RoW, while this significance is lost when we compare March 2019 to April 2020, with exception made for SPECT, PET and CCTA. Absolute numbers are presented as raw data in Supplementary Table 3.

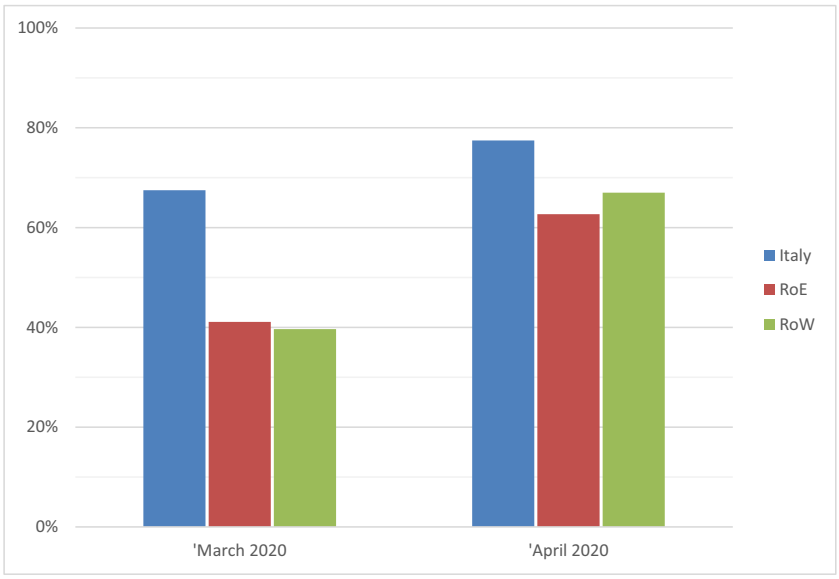

Fig. 2. Volume reduction for Italy, Rest of Europe (RoE), and Rest of World.

Table 2
Breakdown of the reduction of cardiac imaging tests among the three Italian macro-regions [IQR = Interquartile Range].

	Italy	North	Centre	South	p
Number of Centres	52	15	28	9	
Number of procedures					
March 2019	25,579	14,105	8874	2600	
March 2020	8318	5057	2730	531	
April 2020	5763	3271	2124	368	
Procedures/ center, median [IQR]					
March 2019	215 [62–1013]	215 [60–1013]	223 [81–1208]	90 [37–398]	0.334
March 2020	70 [15–261]	74 [22–335]	120 [36–280]	20 [8–38]	0.114
April 2020	32 [10–160]	36 [8–171]	47 [20–247]	12 [10–30]	0.293

Statistical analysis (Table 5) shows that cardiac testing in Italy decreased homogeneously without any statistically significant difference among the three Italian regions across the different procedures in both periods. No factors or characteristics considered in our study were associated with procedure volume reduction in Italy using a multivariable linear regression analysis. Absolute numbers are presented as raw data in Supplementary Table 4.

4. Discussion

This study is a sub-analysis of data collected from Italy as part of a wider worldwide survey [3] about the effects of the COVID-19 pandemic on the delivery of diagnostic testing and imaging of CVD. Results show that in Italy, during the surveyed period, the overall practice of cardiac imaging was heavily affected, down of 67% from March 2019 to March 2020, and of a further 10% until April 2020, reaching a total of 77% in April 2020 as compared to March 2019-. The rapid decrease of cardiac procedures are the consequence of the earlier lockdown and the decisions taken by healthcare authorities, stricter than in many other European countries. This is clearly reflected in Table 3 which shows a significantly higher decrease in Italy in March 2020 as compared to RoE and RoW where countries have been affected a few weeks later. However, after other countries took the same actions [7], the differences in production become no longer statistically significant in April 2020. This is due to a lower volume decrease from March 2020 to April 2020 in Italy, as compared to both RoE and RoW, as shown in Table 4. Most likely, in March the impact of the very strict containment measures had already affected production in Italy while they were still to impact RoE. Indeed, the 10% further reduction in cardiac imaging procedures registered from March 2020 to April 2020 was significantly smaller in Italy than in Europe or worldwide (Table 5; $p = 0.005$).

At the level of the three regions as identified in Fig. 1, the decrease of cardiac imaging procedures has been homogeneous across the board, with the five modalities involving a stressor test more heavily affected than the others, possibly in relation to greater risks carried by these tests because of aerosolization. Of note, for all modalities, with exception of CACS and PET infection, the decrease in volumes was higher, and statistically significant, than RoE and RoW (Table 5). Therefore, the reduction of non-invasive cardiovascular imaging, which has a fundamental role in modern healthcare with a robust evidence of its diagnostic and prognostic role as shown by numerous studies [8–13], may compromise the clinical outcome of many patients.

Table 3
Reduction in total procedures in percentage.

	Italy				Worldwide			
	Centre	North	South	p	Italy	RoE	RoW	p
Reduction in total procedures, %								
March 2019 to March 2020	69%	64%	80%	0.467	67%	41%	40%	**<0.001**
March 2020 to April 2020	7%	13%	6%	0.752	10%	22%	27%	**0.005**
March 2019 to April 2020	76%	77%	86%	0.369	77%	63%	67%	0.164

Bold values indicate changes are statistically significant.

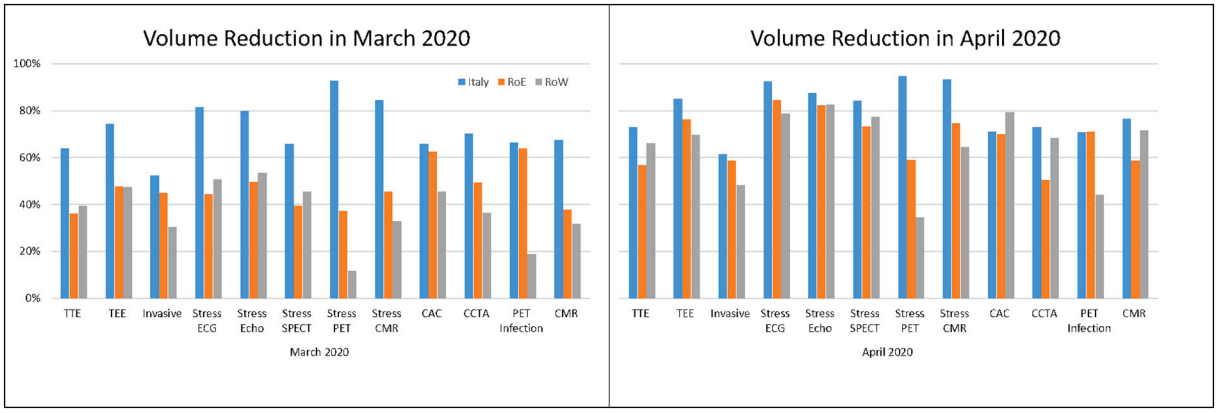

Fig. 3. Volume reduction for Italy, Rest of Europe, and Rest of World by Diagnostic Test in March 2020 an April 2020 as compared to March 2019.

Table 4
Reduction by test in Italy, in order of magnitude, as compared to RoE and RoW in the two periods, March 2019 to March 2020 and March 2019 to April 2020.

	March 2019–March 2020, by test				March 2019–April 2020, by test			
	Italy	RoE	RoW	p	Italy	RoE	RoW	p
Stress PET	93%	37%	12%	**0.008**	95%	59%	34%	**0.009**
Stress CMR	84%	46%	33%	**0.031**	93%	75%	65%	0.349
Stress ECG	81%	44%	51%	**<0.001**	93%	85%	79%	0.434
Stress Echo	80%	50%	54%	**0.005**	88%	82%	83%	0.552
TEE	74%	48%	47%	**0.022**	85%	76%	70%	0.206
CCTA	70%	49%	37%	**<0.001**	73%	50%	68%	**0.002**
CMR	68%	38%	32%	**0.000**	77%	59%	72%	0.202
Stress SPECT	66%	39%	46%	**<0.001**	84%	73%	78%	**0.006**
PET infection	66%	64%	19%	0.108	71%	71%	44%	0.051
CACS	66%	63%	46%	0.888	71%	70%	79%	0.534
TTE	64%	36%	40%	**<0.001**	73%	57%	66%	0.101
ICA	52%	45%	31%	**0.009**	61%	59%	48%	0.386

Bold values indicate changes are statistically significant.

Table 5
Reduction by test by region in Italy, in order of magnitude.

Type of test	March 2019–March 2020				Type of test	March 2019–April 2020			
	Centre	North	South	p		Centre	North	South	p
Stress echo	86%	74%	84%	0.268	Stress echo	94%	83%	86%	0.851
TEE	85%	63%	94%	0.912	TEE	89%	80%	97%	0.616
Stress CMR	81%	96%	54%	0.202	Stress CMR	93%	94%	92%	0.925
CACS	80%	80%	10%	0.472	CACS	70%	100%	30%	0.368
Stress ECG	78%	83%	83%	0.743	Stress ECG	87%	96%	90%	0.525
CMR	77%	59%	75%	0.264	CMR	86%	68%	82%	0.020
PET infection	76%	53%	83%	0.089	PET infection	91%	50%	89%	0.209
Stress PET	69%	93%	96%	0.844	Stress PET	100%	97%	94%	0.651
CCTA	68%	71%	81%	0.823	CCTA	73%	72%	77%	0.,840
TTE	68%	60%	73%	0.448	TTE	69%	74%	85%	0.353
Stress SPECT	64%	62%	83%	0.889	Stress SPECT	84%	85%	84%	0.123
ICA	49%	53%	61%	0.777	ICA	63%	60%	77%	0.489

The lockdown was decreed for the entire country, implying a reduction of diagnostic procedures all over Italy therefore reducing the ability to adequately assess patients with known or suspected IHD regardless of impact of pandemic. Indeed, the Centre and the South were much less affected than the North. However, since the national healthcare system is not uniformly distributed all over the country with areas where the access to care facilities and the availability of intensive care is limited, it could be assumed that the national lockdown has contributed to protect the Centre and South from a possible devastating effect of the pandemic.

During March and April 2020, a dramatic reduction in the number of hospitalizations for myocardial infarction and heart failure was seen, initially in Italy and later in many other countries [14–16]. A study covering Italian CCUs [17], reports a reduction of almost 50% of admission rates for acute myocardial infarction. Fatality and complication rates were comparatively higher in comparison to the previous year, with an increase in mortality rate up to 13.7% from 4.1% registered in the same period in 2019, possibly due to an increase of 39% of the time from symptoms to admission and revascularization [18]. The same study has found a 47% reduction of hospitalization for heart failure as compared to the same period of 2019, equally involving males and females. Hospitalization for atrial fibrillation was reduced by 53% and of almost 30% for either device failure and pulmonary embolism, which could be a result of the excess burden on the health systems, in addition to reduced demand and supply of other non-COVID healthcare services. A similar trend has been reported for access to emergency departments

elsewhere [19].

A recent Italian study [20] has found a sharp decline by 32% of primary PCI rates in ACS during the outbreak of COVID-19, as compared to the same period in the previous year. Furthermore, in a paper covering only one of the imaging procedures surveyed in this study (SPECT MPI), it has been reported that the total number of studies decreased by more than two-thirds during the pandemic in comparison to the average of the same period of the previous three years, but the incidence of positive tests did not [21]. Most likely the same concept could be applied to all the other cardiac diagnostic modalities.

On a wider picture, not only limited to cardiac diseases and based on data released by the Italian Institute of Statistics (ISTAT) [22,23], from February to November 2020 all over the country there is an excess of 83,985 deaths as compared to the average in the same period in the previous 5 years. While at least 57,647 are confirmed COVID-19 victims, i.e. 69% of the excess mortality, a sizeable proportion of the remaining 26,338 could be considered as indirectly caused by the delays and limitations of healthcare provision induced by the pandemic. In the period 1st March to 15th April, the increase in mortality was much higher in the North of the country, the hardest hit of the three macro-regions with the excess mortality up to 168.2% in Lombardy. Notably, in that macro-region, an important component ranging from 38% to 56% is not attributed to the COVID-19 outbreak [24], according to the COVID 19 surveillance. That observation refers to all-cause mortality, including ischemic heart disease which remains the leading cause of death in 2019, as reported by the Global Heath Observatory of WHO [25].

Results of this study, already confirmed in the worldwide survey [3] raise concerns about the reduced utilisation of cardiac imaging testing and hence the possible disruption of primary and secondary prevention strategies [26,27]. Potentially, it could also impact on the general trend of a significant decline in mortality from ischemic heart disease and myocardial infarction, as reported by the World Health Organization and the United Nations [28,29] over the last 25 years.

Although we have documented a serious impact on the delivery of cardiac imaging, it is well accepted that imaging procedures in general are overused, and cardiac imaging is no exception. The need of filtering patient access to medical facilities according to new guidelines due to the pandemic, might well have reduced inappropriate referrals for cardiac imaging in general, as already reported for one of the procedures surveyed in our paper [30].

4.1. Study limitations

Sites were recruited on a voluntary basis after reaching out for participants involved in a range of cardiac procedures, using databases from either IAEA and relevant scientific societies, as well as social media and personal connections. Therefore, a clear picture of the response rate is not possible and is unclear to what extent they are representative of the actual situation for each country. As regards the effects of the pandemic, it spread at a different pace in other continents, resolving earlier in Asia and affecting later the West. Therefore, comparisons with RoW might not be entirely correct. As regards Italy, the explanations given to for the excess mortality cannot be certified and certainly require more sophisticated statistical analysis, however it's a fact that the COVID-19 outbreak has halted and reversed a trend towards an overall reduction of mortality seen in January and February 2020.

5. Conclusions

In March and April 2020, due to the COVID-19 pandemic, the Italian National health care system was stressed, and usual delivery of care was delayed, as confirmed in this study by the striking reduction of cardiac imaging all over the country. As a consequence, a significant number of patients did not perform cardiac imaging tests, potentially leading to the miss of numerous diagnoses and life-saving procedures. Given the fundamental role of cardiac imaging in healthcare programs, there is an absolute need to reorganize our departments in order to provide access to both infected and non-infected patients without reducing the safety of healthcare professionals.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcard.2021.08.044.

Authorship statement

All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

Declaration of Competing Interest

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