Liou et al. Alteration of taste and smell in COVID-19 – A systematic review and meta-analysis

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# Methods

Studies that reported the frequency of alteration in taste (dysgeusia, hypogeusia, ageusia) or smell (dysosmia, hyposmia, anosmia) in patients with laboratory confirmed COVID-19 cases and/or uninfected controls were eligible. Case reports and studies which only included patients with taste or smell alteration were excluded. Review articles or comments on other original studies were also excluded. The references of these articles were also searched for eligibility. The proportion of these symptoms in cases and/or controls and their 95% confidence interval (95% CI) and odds ratio (OR) were analyzed by random effect model using the Comprehensive Meta-analysis software.

Ref.	Author	Assessment of taste or smell alteration	Diagnosis of COVID-19
1	Lechien <sup>1</sup>	National Health and Nutrition Examination Survey, and the short	
		version of the Questionnaire of Olfactory Disorders-Negative Statements (sQOD-NS).	RT-PCR
2	Roland	UCSF COVID-19 Symptom Survey	Self-reported positive test
3	Yan-1	27-question survey	RT-PCR
4	Beltran-Corbellini	self-reported symptoms	RT-PCR
5	Мао	self-reported symptoms	RT-PCR
6	Giacomelli	self-reported symptoms	RT-PCR
7	Lee	telephone interview	RT-PCR
8	Aggarwal	interview	RT-PCR
9	Moein	University of Pennsylvania Smell	RT-PCR
		Identification Test (UPSIT) & symptoms	
10	Luers	Total Nasal Symptom Score (TNSS)	RT-PCR
11	Paderno	questionnaire	RT-PCR
12	Vaira	chemosensitive test	RT-PCR
13	Yan-2	self-reported symptoms	RT-PCR
14	De Maria	self-reported symptoms	RT-PCR
15	Merza	self-reported symptoms	RT-PCR
16	Spinato	telephone interview	RT-PCR
17	Clemency	interview	RT-PCR
18	Menni	app-based symptom tracker	RT-PCR

Supplementary Table 1. Additional characteristics of eligible studies

Ref: reference; COVID-19: coronavirus infectious disease 2019; RT-PCR: reverse transcriptase polymerase chain reaction.

# **Supplementary Figures**

# Figure S1. Forrest plots of the proportion of taste alteration in COVID-19 patients

Study name		Statisti	cs for ea	ach study	_			Event	rate and §	95% CI
	Event rate	Lower limit	Upper limit	Z-Value	p-Value	Total				
Lechien	0.888	0.853	0.916	12.816	0.000	342 / 385				
Yan-1	0.712	0.584	0.813	3.146	0.002	42 / 59				-
Beltran-Corbellini	0.354	0.257	0.465	-2.549	0.011	28 / 79				-∎-
Mao	0.009	0.002	0.037	-6.564	0.000	2/214				
Giacomelli	0.288	0.187	0.416	-3.146	0.002	17 / 59			- 1	-
Lee	0.122	0.111	0.134	-36.493	0.000	389 / 3191				
Aggarwal	0.188	0.062	0.447	-2.289	0.022	3 / 16			-	
Luers	0.685	0.570	0.781	3.082	0.002	50 / 73				-
Paderno	0.630	0.587	0.671	5.788	0.000	320 / 508				
Vaira	0.515	0.349	0.678	0.174	0.862	17 / 33				
Yan-2	0.583	0.493	0.668	1.817	0.069	70 / 120				
De Maria	0.505	0.406	0.604	0.103	0.918	48 / 95				-
	0.413	0.211	0.650	-0.707	0.480				-	$\bullet$
							-1.00	-0.50	0.00	0.50

Heterogeneity: Q=1160, I<sup>2</sup>=99.1%, p<0.001

# Figure S2. Forrest plots of the proportion of smell alteration in COVID-19 patients

Study name		Statistics for each study							
	Event rate	Lower limit	Upper limit	Z-Value	p-Value	Total			
Lechien	0.856	0.819	0.887	12.782	0.000	357 / 417			
Yan-1	0.678	0.549	0.784	2.672	0.008	40 / 59			
Beltran-Corbellini	0.316	0.224	0.427	-3.184	0.001	25 / 79			
Mao	0.009	0.002	0.037	-6.564	0.000	2/214			
Giacomelli	0.237	0.146	0.362	-3.815	0.000	14 / 59			
Lee	0.111	0.100	0.122	-36.932	0.000	353 / 3191			
Aggarwal	0.188	0.062	0.447	-2.289	0.022	3 / 16			
Moein	0.983	0.891	0.998	4.043	0.000	59 / 60			
Luers	0.726	0.613	0.816	3.714	0.000	53 / 73			
Paderno	0.559	0.516	0.602	2.656	0.008	284 / 508			
Vaira	0.515	0.349	0.678	0.174	0.862	17 / 33			
Yan-2	0.586	0.499	0.668	1.935	0.053	75 / 128			
	0.453	0.233	0.694	-0.365	0.715				
							-1.00		

Heterogeneity: Q=1168, I<sup>2</sup>=99%, p<0.001

Event rate and 95% CI

-0.50

0.00

1.00

1.00

0.50

#### Figure S3. Forrest plots of the proportion of taste or smell alteration in COVID-19

#### patients

Study name		Statisti	cs for ea	ach study			Event rate and 95% CI				
	Event rate	Lower limit	Upper limit	Z-Value	p-Value	Total					
Roland	0.655	0.574	0.728	3.674	0.000	95 / 145	1			🖶	
Beltran-Corbellini	0.392	0.291	0.504	-1.898	0.058	31 / 79				-	
Giacomelli	0.339	0.230	0.468	-2.428	0.015	20 / 59			- I -		
Lee	0.153	0.141	0.166	-34.804	0.000	488 / 3191					
Moein	0.350	0.241	0.478	-2.287	0.022	21 / 60					
Yan-2	0.757	0.687	0.816	6.344	0.000	128 / 169					
Merza	0.267	0.104	0.533	-1.733	0.083	4 / 15			-1	∎→	
Spinato	0.644	0.575	0.707	4.022	0.000	130 / 202					
Clemency	0.489	0.424	0.554	-0.333	0.739	110 / 225					
Menni	0.650	0.639	0.661	25.067	0.000	4668 / 7178					
	0.466	0.270	0.673	-0.310	0.756						
							-1.00	-0.50	0.00	0.50	1.00

Heterogeneity: Q=1870, I<sup>2</sup>=99.5%, p<0.001

Asia versus non-East Asia

#### Figure S4. Forrest plots of the proportion of taste alteration in COVID-19 patients in East

#### Study name Statistics for each study Event Lower Upper rate limit limit Z-Value p-Value Total 0.000 342 / 385 Lechien 0.888 0.853 0.916 12.816 Yan-1 0.712 0.584 0.813 3.146 0.002 42 / 59 Beltran-Corbellini 0.354 0.257 0.465 -2.5490.011 28/79 0.009 0.002 0.037 -6.564 0.000 2/214 Mao Giacomelli 0.288 0.187 0.416 -3.146 0.002 17/59 0.122 0.134 -36.493 0.000 389/3191 0.111 Lee Aggarwal 0.188 0.062 0.447 -2.289 0.022 3/16 0.570 0.781 0.002 50/73 Luers 0.685 3.082 Paderno 0.630 0.587 0.671 5.788 0.000 320 / 508 0.515 0.349 0.678 0.174 0.862 17/33 Vaira Yan-2 0.583 0.493 0.668 1.817 0.069 70/120 0.406 0.918 48 / 95 0.505 0.604 0.103 De Maria 0.413 0.211 0.650 -0.707 0.480

Heterogeneity: Q=160.4, I<sup>2</sup>=94.4%, p<0.001

Statistics for each study Study name **Event Lower Upper** limit Z-Value p-Value Total rate limit 0.009 0.002 0.037 -6.564 0.000 2/214 Mao 0.122 0.111 0.134 -36.493 0.000 389/3191 Lee 0.038 0.003 0.355 -2.405 0.016









Figure S5. I	Forrest plot of the	association of taste of	r smell alteration and	l COVID-19
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Study name		Statis	tics for ea	ch study		Taste/sn	nell / Total		Odds ratio and 95% Cl			
	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value	Cases	Controls					
Roland	5.202	3.181	8.510	6.569	0.000	95 / 145	42 / 157					
Yan	11.859	6.063	23.195	7.225	0.000	42 / 59	35 / 203				_ <b></b>	
Beltran-Corbe	llini4.521	1.598	12.793	2.843	0.004	31 / 79	5 / 40			I –		
Moein	65.861	3.877	1118.693	2.898	0.004	21 / 60	0 / 60				_	
Clemency	5.562	3.992	7.750	10.140	0.000	110 / 225	108 / 736					
Menni	6.708	6.279	7.167	56.448	0.000	4668 / 7178	2436 / 11223					
	6.493	5.206	8.097	16.604	0.000						<b>♦</b>	
								0.01	0.1	1	10	100

Heterogeneity: Q=1160, I<sup>2</sup>=99.1%, p<0.001

Figure S6. Forrest plot of (A) sensitivity, (B) specificity, (C) Positive prediction value, (D) Negative prediction value, and (E) Accuracy of taste or smell alteration in the prediction of COVID-19

# (A)Sensitivity

Study name		Statisti	ics for ea	ach study	-			Event rate and 95% CI			
	Event rate	Lower limit	Upper limit	Z-Value	p-Value	Total					
Roland	0.655	0.574	0.728	3.674	0.000	95 / 145				🖶	
Yan	0.712	0.584	0.813	3.146	0.002	42 / 59				- E	F
Beltran-Corbellini	0.392	0.291	0.504	-1.898	0.058	31 / 79					
Moein	0.350	0.241	0.478	-2.287	0.022	21 / 60				-ॖॖॖॖॖॖ_	
Clemency	0.489	0.424	0.554	-0.333	0.739	110 / 225					
Menni	0.650	0.639	0.661	25.067	0.000	4668 / 7178					
	0.548	0.443	0.649	0.895	0.371					•	
							-1.00	-0.50	0.00	0.50	1.00

Heterogeneity: Q=65.1, I<sup>2</sup>=92.3%, p<0.001

# (B)Specificity

Study name		Statisti	Statistics for each study						
	Event rate	Lower limit	Upper limit	Z-Value	p-Value	Total			
Roland	0.732	0.658	0.796	5.587	0.000	115 / 157			
Yan	0.828	0.769	0.874	8.442	0.000	168 / 203			
Beltran-Corbellini	0.875	0.733	0.947	4.070	0.000	35 / 40			
Moein	0.992	0.882	0.999	3.377	0.001	60 / 60			
Clemency	0.853	0.826	0.877	16.899	0.000	628 / 736			
Menni	0.783	0.775	0.790	56.028	0.000	8787 / 11223			
	0.817	0.765	0.859	9.409	0.000				



0.00

0.50

1.00

-1.00

-0.50

Heterogeneity: Q=32.6, I<sup>2</sup>=84.7%, p<0.001

# (C) Positive prediction value

Study name		Statisti	ics for ea	ach study	-		Event rate and 95% CI				
	Event rate	Lower limit	Upper limit	Z-Value	p-Value	Total					
Roland	0.693	0.611	0.765	4.405	0.000	95 / 137				-	F F
Yan	0.545	0.434	0.653	0.797	0.426	42 / 77				- <b></b>	
Beltran-Corbellini	0.861	0.707	0.941	3.786	0.000	31 / 36				-	-=-
Moein	0.977	0.723	0.999	2.629	0.009	21/21					_
Clemency	0.505	0.439	0.570	0.135	0.892	110 / 218					
Menni	0.657	0.646	0.668	26.020	0.000	4668 / 7104					
	0.652	0.559	0.734	3.160	0.002					_   ₹	
							-1.00	-0.50	0.00	0.50	1.00

Heterogeneity: Q=36.8, I<sup>2</sup>=86.4%, p<0.001

# (D) Negative prediction value



Event rate and 95% CI

Heterogeneity: Q=107.8, I<sup>2</sup>=95.4%, p<0.001

### (E) Accuracy



Heterogeneity: Q=34.9, I<sup>2</sup>=85.7%, p<0.0001

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