# Detecting bulbar amyotrophic lateral sclerosis (ALS) using automatic acoustic analysis

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### **Background and hypotheses**

ALS frequently causes speech impairment [1], and remote speech assessment has much potential for ALS detection. It will be critical in clinical validation of these systems to evaluate disease detection, particularly early signs of disease.

We clinically validated an automated speech assessment (Winterlight Labs) for detecting ALS, including at an early stage.

We **hypothesized** that acoustic features could distinguish:

- (1) ALS patients from control participants,
- (2) Early ALS (ALS-E) patients from control participants, and
- (3) Early ALS (ALS-E) from late ALS (ALS-L) patients.

#### Methods





**Extract 53 acoustic features**: jitter/ shimmer, fundamental frequency ( $F_0$ ), pause durations, etc. using an automated acoustic analysis pipeline.



ALS-E (ALSFRS bulbar ≥11) ALS-L (ALSFRS bulbar <11).



**Classify:** Bayesian sparse logistic regression; average area under receiver operating characteristic curve (AUROC) from 10 held-out test sets

	ALS	Control				
N (%F)	121 (47)	22 (45)				
nce onset	59 (41)	_				
-R bulbar	11 (4)	-				

Values for yrs since onset and ALSFRS-R bulbar are median (interquartile range).

#### Results

Strongest feature weights capture disease progression across ALS severities.

PO     FO     max     0.38     0.35     0.28       FO     FO     FO     meaia     0.39     0.41     0.36       FO     range     0.32     0.36     0.36     0.36       hnr     ac     mean     0.32     0.36     0.36       hnr     ac     mean     0.32     0.36     0.36       hnr     ac     mean     0.32     0.36     0.36       hnr     ac     mean     0.36     0.36     0.36       hnr     ac     mean     0.32     0.36     0.36     0.36       hnr     ac     max     -     -     -     -     -       hnr     ac     max     -	Feature weights (top 25% per comparison)					
P0_mean     0.28       F0_median     0.39     0.41       F0_range     0.32     0.36       F0_range     0.32     0.36       hnr_ac_max     0.32     0.36       hnr_ac_mean     0.32     0.36       hnr_ac_mean     0.32     0.36       hnr_ac_mean     0.26     0.36       hnr_ac_mean     0.26     0.36       hnr_ac_mean     0.26     0.36       hnr_ac_mean     0.26     0.36       hnr_ac_max     0.26     0.36       hnr_cc_max     0.37     0.36       hnr_cc_maan     0.31     0.36       int_mean_db     0.31     0.36       int_man sones     0.32     0.31       int_man sones     0.32     0.32       int_man sones     0.32     0.31       int_man sones     0.32     0.31       int_man sones     0.32     0.32       int_man sones     0.32     0.32       jitter_local     0.31     0.36       jitter_ddp		F0 max -	0.38	0.35		
Pice     F0_median F0_min     0.39     0.41       F0_range F0_var     0.32     0.36       Hnr_ac_max	0	F0 mean -			0.28	
Image     F0 min     0.39     0.41       F0 mage     0.39     0.41       F0 mage     0.32     0.36       hnr ac max		F0 median				
F0 range F0 var F0 var     0.39     0.41       F0 var F0 var     0.32     0.36       hnr ac max     0.26     0.16       hnr_ac_main     0.26     0.16       hnr_ac_max     0.26     0.16       hnr_ac_max     0.26     0.16       hnr_ac_max     0.26     0.16       hnr_ac_max     0.26     0.16       hnr_cc_max     0.16     0.16       hnr_cc_max     0.16     0.16       hnr_cc_max     0.28     0.36       int_mean_db     0.31     0.36       int_mean_db     0.32     0.35       int_mean_sones     0.32     0.35       int_mean_sones     0.32     0.36       int_mean_sones     0.32     0.33       int_mean_sones     0.32     0.31       int_mean_sones     0.32     0.33       int_mean_sones     0.32     0.31       int_mean_sones     0.32     0.31       int_mean_sones     0.32     0.29       jitter_local     0.31     0.38		F0 min -			0.36	
F0 var     0.32     0.36       hnr ac mean     -     -       hnr ac mean     -     -       hnr ac mean     -     -       hnr ac max     -     -       hnr ac mean     -     -       hnr ac max     -     -       hnr cc max     -     -       int_mean db     -     -       int_mean db     -     -       int_mean sones     -     -       int_max     -     -     -       int_mean sones     -     -     -       int_mean sones     -     -     -       int_max     -     -     -     -       jitter_local     -		F0 range -	0.39	0.41		
Yet     hnr_ac_max hnr_ac_mean hnr_ac_mean hnr_ac_mean hnr_ac_mean hnr_ac_mean hnr_ac_mean hnr_ac_range     -0.26       Yet     hnr_ac_mean hnr_ac_var     -0.26       hnr_ac_mean hnr_ac_var     -0.26       hnr_ac_max hnr_ac_war     -0.26       hnr_ac_max hnr_ac_war     -0.26       hnr_ac_war     -0.26       hnr_ac_war     -0.26       hnr_cc_mean hnr_cc_mean     -0.28       int_mean_ab int_mean_sones     -0.32       int_mean_sones     -0.32       int_mean_sones     -0.32       int_mean int_range     -0.29       int_reap     -0.29       jitter_local jitter_local jitter_paps     -0.29       jitter_local absolute     -0.29       jitter_local jitter_app     -0.29       jitter_app     -0.26       jitter_app     -0.26       jitter_app     -0.26       jitter_app     -0.28       shimmer_app3     -0.29       shimmer_app3     -0.29       shimmer_app3     -0.28       shimmer_local     -0.34       Short_pause_dur     -0.34		F0 var -	0.32	0.36		
Yet     hnr_ac_mean     -0.26     hnr_ac_man       hnr_ac_mia     -0.26     hnr_ac_man     -0.26       hnr_ac_man     -     -     -       hnr_ac_man     -     -     -       hnr_ac_man     -     -     -       hnr_cc_man     -     -     -       int_mean_sones     -     -     -       int_mean_sones     -     -     -       int_mean_sones     -     -     -       jitter_local_absolute     -     -     -       jitter_local_absolute     -     -     -		hnr ac max -				
Y     hnr ac_median hnr_ac_range     -0.26       hnr_ac_range		hnr_ac_mean -				
Yet     hnr_ac_min     hnr_ac_min       Image: hnr_ac_var     image: hnr_ac_var     image: hnr_ac_var       hnr_cc_max     image: hnr_ac_min     image: hnr_ac_var       hnr_cc_median     image: hnr_ac_min     image: hnr_ac_min       hnr_cc_median     image: hnr_ac_min     image: hnr_ac_min       hnr_cc_median     image: hnr_ac_war     image: hnr_ac_min       int_rec_min     int_rec_min     image: hnr_ac_war       int_rec_min     image: hnr_ac_war     image: hnr_ac_war       int_mean_sones     image: hnr_ac_war     image: hnr_ac_war       jitter_local     image: hnr_ac_war     image: hnr_ac_war       jitter_local absolute     image: hnr_ac_war     image: hnr_ac_war       jitter_local absolute     image: hnr_ac_war     image: hnr_ac_war       ind_pause_dur     image: hnr_ac_war     image: hnr_ac_war       med_pause_dur     image: hnr_ac_war     image: hnr_ac_war       <		hnr_ac_median -	-0.26			
Yet     hnr_ac_range - hnr_ac_var     hnr_ac_war       hnr_cc_maan     -     -       hnr_cc_maan     -     -       hnr_cc_maan     -     -       hnr_cc_maan     -     -       hnr_cc_range     -     -       hnr_cc_range     -     -       hnr_mean_db     -     -       int_mean_db     -     -       int_mean_sones     -     -       -0.34     -0.45     -       int_median     -     -       jitter_local     -     -       jitter_local     -     -       jitter_local     -     -       jitter_local     -     -       long_pause_dur		hnr_ac_min -				
Hnr.ac.var     hnr.ac.var       hnr.cc_max		hnr_ac_range -				
Image: Second	$\overline{\mathbf{z}}$	hnr_ac_var -				
L     hnr_cc_mean       hnr_cc_mean	4	hnr_cc_max -				
hnr_cc_min     -       hnr_cc_range     -       hnr_cc_range     -       int_mean,db     -       int_mean,db     -       int_mean,db     -       int_mean,db     -       int_mean,db     -       int_mean,sones     -       int_mean,sones     -       int_mean,db     -       int_mean,sones     -       int_mean_sones     -       int_mean     -       int_mean     -       int_mean     -       int_range     -       int_range     -       int_range     -       jitter_local     absolute       jitter_local     -       jitter_local     -       jitter_ap     -       long_pause_dur     -       med_pause_dur     -       med_pause_dur     -       shimmer_apq3     -       shimmer_apq3     -       shimmer_apq3     -       shimmer_local     -	╎┻	hnr_cc_mean -				
hnr_cc_range		hnr_cc_median -				
hnr_cc_range - hnr_cc_var -   -0.28   -0.36     int_mean_db - int_mean_sones - int_median - int_median - int_median - int_mange - int_range - int_range - int_range - int_range - int_range - int_range - int_range - 0.29   -0.37     •   -0.31   -0.36     •   -0.32   -0.35     •   -0.34   -0.445     •   -0.41   -0.38   0.48     •   -   -0.29   0.31     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -     •   -   -   -   -   -     •   -   -   -   -   -   -     •   -   -   -		hnr_cc_min -				
hnr_cc var     -0.28     -0.36       int_mean_db     -0.31     -0.36       int_mean_energy     -0.31     -0.36       int_mean_sones     -0.32     -0.35       int_mean_sones     -0.34     -0.45       int_mean_in     -0.29     -0.29       int_min     -0.29     -0.29       int_range     -0.41     -0.38     0.48       jitter_ddp     -     -     -       jitter_local absolute     -     -     -       go     pause_dur     -     -     -  <		hnr_cc_range -				
int_mean_db     -0.28     -0.36       int_mean_db     -0.31     -0.36       int_mean_energy     -0.31     -0.36       int_median     -0.32     -0.35       int_median     -0.34     -0.45       int_mage     -0.29     0.31       int_range     -0.29     0.31       jitter_local     -0.41     -0.38     0.48       jitter_local     -0.29     -0.26     -0.29       jitter_rap     -     -     -       long_pause_dur     -     -     -       med_pause_dur     -     -     -       med_pause_dur     -     -     -       med_pause_dur     -     -     -       shimmer_apq1     -     -     -       shimmer_apq3     -     -     -       shimmer_local		hnr_cc_var -				
int_mean_db -   -0.37     int_mean_sones -   -0.32   -0.35     int_mean_sones -   -0.34   -0.45     int_man -   0.29   -0.29     int_man -   -0.38   0.48     int_man -   -0.38   0.48     int_range -   -0.29   0.31     int_var   -0.41   -0.38   0.48     jitter_local absolute -   -   -   -     med_pause_dur -   -   -   -   -     med_pause_dur -   -   -   -   -     pause_word_ratio -   0.3   0.26   -     shimmer_apq1   -   -   -   -     gashimmer_local -   -   -   -   -	Int.	int_max -	-0.28	-0.36		
int_mean_energy -   -0.31   -0.36     int_mean_sones -   -0.32   -0.35     int_min -   0.29   -0.29     int_range -   -0.41   -0.38   0.48     inter_ddp -   -   -   -     itter_local absolute -   -   -   -     jitter_local absolute -   -   -   -     ijtter_local -   -   -   -   -     long_pause_dur -   -   -   -   -     med_pause_dur -   -   -   -   -     med_pause_dur -   -   -   -   -     shimmer_apq11   -   -   -   - </td <td>int_mean_db -</td> <td></td> <td></td> <td>-0.37</td>		int_mean_db -			-0.37	
int_mean_sones   -0.32   -0.35     int_median   -0.34   -0.45     int_min   0.29   -0.29     int_range   -0.29   0.31     int_var   -0.41   -0.38   0.48     jitter_local   jitter_local   -0.29   -0.29     jitter_local absolute   -   -   -     jitter_rap   -   -   -   -     long_pause_ct_norm   -   -   -   -     med_pause_dur   -   -   -   -     med_pause_dur   -   -   -   -     med_pause_dur   -   -   -   -     short_pause_dur   -   -   -   -     short_pause_dur   -   -   -   -     shimmer_apq3   -   -   -   -   -     Short_pause_dur   -   -   - <td>int_mean_energy -</td> <td>-0.31</td> <td>-0.36</td> <td></td>		int_mean_energy -	-0.31	-0.36		
int_median   -0.34   -0.45     int_min   0.29   -0.29     int_range   -0.29   0.31     int_var   -0.41   -0.38   0.48     jitter_local   jitter_local   -0.29   0.31     jitter_local_absolute   -   -   -     jitter_app3   -0.29   -0.26   -     med_pause_dur   -   -   -     med_pause_dur   -   -   -     pause_word_ratio   0.3   0.26   -     shimmer_apq3   -0.29   -   -     shimmer_apq3   -0.29   -   -     shimmer_local_db   -   -   -     V   zcr_kurosis   -   - <td>int_mean_sones -</td> <td>-0.32</td> <td>-0.35</td> <td></td>		int_mean_sones -	-0.32	-0.35		
int_min   0.29   -0.29     int_range   -0.29   0.31     int_var   -0.41   -0.38   0.48     jitter_ddp   -   -   0.41   -0.38   0.48     jitter_local   -   -   0.41   -0.38   0.48     jitter_local   -   -   -   0.43   -     jitter_local absolute   -   -   -   -   -     jitter_local absolute   -   -   -   -   -   -     jitter_local absolute   - <td>int_median -</td> <td>-0.34</td> <td>-0.45</td> <td></td>		int_median -	-0.34	-0.45		
0.29   0.31     int_var   -0.41   -0.38   0.48     jitter_local   jitter_local   0.41   -0.38   0.48     jitter_local_absolute   -0.29   -0.26   0.31     jitter_local_absolute   -0.29   -0.26   0.31     jitter_local_absolute   -0.29   -0.26   0.31     jitter_local_absolute   -0.29   -0.26   0.31     jitter_rap   -0.29   -0.26   0.31     long_pause_ct_norm   -0.28   -0.26   0.33     med_pause_dur   -0.33   0.26   0.26     pause_word_ratio   -0.34   -0.28   -0.26     shimmer_apq3   -0.29   -0.34   -0.34     shimmer_local   -0.34   -0.34   -0.34     Shimmer_local_db   -0.28   -0.26   -0.26     Zcr_kurtosis   -0.26   -0.26   -0.26     Zcr_skewness   -0.26   -0.26   -0.26     Zcr_skewness   -0.25   0.45   -0.61     avg_word_dur   -0.36   -0.41   -0.61     yphonation_rate		int_min -		0.29	-0.29	
int_var   -0.41   -0.38   0.48     jitter_iddp   -   -   -     jitter_local absolute   -   -   -     jitter_local absolute   -   -   -     jitter_local absolute   -   -   -     jitter_ppq5   -0.29   -0.26   -     jitter_rap   -   -   -     long_pause_dur   -   -   -     med_pause_dur   -   -   -     med_pause_dur   -   -   -     pause_word_ratio   0.3   0.26     short_pause_dur   -   -   -     shimmer_apq3   -0.29   -   -     shimmer_apq3   -0.29   -   -     shimmer_apq3   -0.29   -   -     shimmer_local   -   -   -     sh		int_range -		-0.29	0.31	
jitter_ddp -   jitter_local -     jitter_local absolute -   -0.29     jitter_local absolute -   -0.29     jitter_rap -   -0.29     long_pause_ct_norm -   -     long_pause_dur -   -     med_pause_dur -   -     med_pause_dur -   -     pause_word_ratio -   0.3     short_pause_dur -   -     shimmer_apq3 -   -0.29     shimmer_apq3 -   -0.28     shimmer_local -   -     shimmer -   -   -		int_var -	-0.41	-0.38	0.48	
itter_local -   itter_local -     itter_local absolute -   .0.29     itter_pap5 -   .0.29     itter_rap -	it.	jitter_ddp -				
Jitter_local_absolute -     jitter_ppq5     jitter_rap     long_pause_ct_norm -     long_pause_dur -     med_pause_dur -     med_pause_dur -     med_pause_dur -     pause_word_ratio -     short_pause_ct_norm -     short_pause_dur -     short_pause_dur -     shimmer_apq11 -     shimmer_apq5 -     shimmer_local_db -     shimmer_local_db -     shimmer_local_db -     zcr_kurtosis -     zcr_kurtosis -     zcr_skewness -     articulation_rate -     avg_word_dur -     speech_rate -     0.25     0.41		Jitter_local -				
Image: Second		Jitter_local_absolute -	0.20	0.00		
Inter_rap     Ing_pause_ct_norm     Ing_pause_dur     med_pause_dur     med_pause_dur     med_pause_dur     med_pause_dur     pause_word_ratio     pause_dur     pause_dur     pause_dur     short_pause_dur     shimmer_apq11     shimmer_apq3     shimmer_apq3     shimmer_local     shimmer_local_db     shimmer_local_db     zcr_kurtosis     zcr_war     phonation_rate     articulation_rate     avg_word_dur     speech_rate     0.36     OA	) it	Jitter_ppq5 -	-0.29	-0.26		
Image pause _ct_norm	<b>)</b>	Jitter_rap -				
Og neal pause_dur - mean_pause_dur - med_pause_ct_norm - med_pause_dur - pause_word_ratio - 0.3   0.3   0.26     Short_pause_ct_norm - short_pause_dur - shimmer_apq110.28   -0.28   -0.29     Shimmer_apq30.29   -0.34   -0.34     Shimmer_local - shimmer_local - shimmer_local - shimmer_local - shimmer_local - co.38   -0.34   -0.34     YON   Zcr_kurtosis - Zcr_wara - 2cr_skewness - 2cr_var - 2cr_skewness - 2cr_var - 2cr_		l long_pause_ct_norm -				
With an pause_dur - med_pause_dur - med_pause_dur - med_pause_dur - pause_word_ratio - 0.3   0.3   0.26     Pause_word_ratio - pause_dur - pause_dur - short_pause_dur - 0.28   -0.28   -0.28     Shimmer_apq10.28   -0.34   -0.34     Shimmer_apq50.34   -0.34   -0.34     Shimmer_local - shimmer_local - shimmer_local - db - speech_rate - 0.25   -0.26     Y   Zcr_kurtosis - 2cr_var - 2cr_var - 2cr_var - 2cr_skewness - 2cr_skewness - 2cr_skewness - 2cr_var - 2cr_va		long_pause_dur -				
med_pause_dur   -   0.3   0.26     med_pause_dur   -   0.3   0.26     short_pause_dtr   -   -   0.3   0.26     short_pause_dur   -   -   0.28   -     shimmer_apq3   -   -   0.34   -   0.34     shimmer_apq5   -   -   0.34   -   0.34     Shimmer_local   -   -   -   -   -   -     Shimmer_local_db   - <td><b>U</b></td> <td>mean_pause_dur -</td> <td></td> <td></td> <td></td>	<b>U</b>	mean_pause_dur -				
Provide and a second		med_pause_ct_norm -				
A   pause_word_ratio   0.3   0.26     short_pause_ct_norm   -   -   0.3   0.26     short_pause_dur   -   -   -   0.28     shimmer_apq11   -0.28   -   -   0.34   -   0.34     shimmer_apq5   -0.34   -0.34   -   0.34   -   0.34     Shimmer_local   -   -   -   -   0.34   -   0.34     Shimmer_local_db   -   -   -   -   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.34   -   0.36   0.25   0.45   -   0.26   -   2   0.26   2   2   0.45   -   0.45   -   0.45   -   0.45   -   0.41   -   0.61   0.41   -	Jal	neu_pause_uur -		0.2	0.26	
Shint_pause_ct_norm -   -0.28     shimmer_apq3   -0.29     shimmer_apq5   -0.34     shimmer_local   -0.3     shimmer_local_db   -0.3     Shimmer_local_db   -0.3     Shimmer_local_db   -0.26     Shimmer_local_db   -0.26     Shimmer_local_db   -0.26     Scr_kewness   -0.26     Zcr_kewness   -0.26     Zcr_var   -0.26     Speech_rate   0.25     O.45   -0.61     Speech_rate   0.36     O.41   -0.61		pause_woru_ratio -		0.5	0.20	
Shiol _ pause_ddi   -0.28     shimmer_apq3   -0.29     shimmer_apq5   -0.34     shimmer_local   -0.3     shimmer_local_db   -0.3     Shimmer_local_db   -0.26     ZCr_kurtosis   -0.26     Zcr_skewness   -0.26     Zcr_var   -0.26     phonation_rate   -0.25     articulation_rate   0.25     avg_word_dur   -0.61     speech_rate   0.36		short pause dur				
Simmer_apq3   -0.29     shimmer_apq5   -0.34     shimmer_dda   -0.3     shimmer_local   -0.3     shimmer_local_db   -0.3     shimmer_local_db   -0.3     g   zcr_kurtosis     zcr_kwrtosis   -0.26     zcr_kwrtosis   -0.26     g   phonation_rate     articulation_rate   0.25     avg_word_dur   -0.61     speech_rate   0.36     Jitt. = Jitter, Shim. = Shimmer,		shimmer and 11		_0.28		
Shimmer_apq5   -0.34   -0.34     Shimmer_dda   -0.3     Shimmer_local   -0.3     Shimmer_local_db   -0.3     Shimmer_local_db   -0.3     Shimmer_local_db   -0.3     V   Zcr_kurtosis     Zcr_mean   -0.26     Zcr_var   -0.26     get   phonation_rate     avg_word_dur   -0.61     speech_rate   0.36     Jitt. = Jitter, Shim. = Shimmer,   ALS	Shim.	shimmer and shimme	-0.20	-0.20		
Shimmer_dda   -0.3     Shimmer_local   -0.3     Shimmer_local_db   -0.3     Shimmer_local_db   -0.3     Shimmer_local_db   -0.3     V   Zcr_kurtosis     Zcr_mean   -0.26     Zcr_skewness   -0.26     Zcr_var   -0.25     P   phonation_rate     avg_word_dur   -0.61     speech_rate   0.36     Jitt. = Jitter, Shim. = Shimmer,   ALS		shimmer and 5	-0.29	-0.34		
Shimmer_local -   0.3     Shimmer_local_db -   -     Speech_rate -   0.36     Shimmer_local_db -   -     Shimmer_local_db -   -     Speech_rate -   0.36		shimmer dda		-0.54		
O)   shimmer_local_db -     Shimmer_local_db -		shimmer local	-0.5			
Y   Zcr_kurtosis     Zcr_mean -     Zcr_skewness -     Zcr_var -     P     phonation_rate -     articulation_rate -     avg_word_dur -     speech_rate -     0.36		shimmer local dh				
Image: Section of the section of th	ZCR	zcr kurtosis				
N   zcr_skewness -   -0.26     zcr_var -   -0.25     phonation_rate -   0.25     articulation_rate -   0.25     avg_word_dur -   -0.61     speech_rate -   0.36     Jitt. = Jitter, Shim. = Shimmer,   AI S		zcr mean -				
N   zcr_var   0.20     phonation_rate   -     articulation_rate   0.25     avg_word_dur   -0.61     speech_rate   0.36     Jitt. = Jitter, Shim. = Shimmer,   ΔI S     ΔI S   ΔI S-F		zcr skewness			-0.26	
Phonation_rate   -0.25   0.45     articulation_rate   0.25   0.45     avg_word_dur   -0.61   -0.61     speech_rate   0.36   0.41     Jitt. = Jitter, Shim. = Shimmer,   ΔI S   ΔI S-F   ΔI S-I		zer_skewness zer_skewness zer_var_			0120	
Ψ articulation_rate0.250.45avg_word_dur-0.61speech_rate0.36Jitt. = Jitter, Shim. = Shimmer,ΔΙ S.FΔΙ S.FΔΙ S.J	te	phonation rate -				
word_dur-0.61speech_rate0.36Jitt. = Jitter, Shim. = Shimmer,ΔΙ S.FΔΙ S.FΔΙ S.J		articulation rate -	0.25		0.45	
ΔISΔIS-FΔIS-I	Ω	ava word dur -			-0.61	
Jitt. = Jitter, Shim. = Shimmer, $\Delta I S = \Delta I S = \Delta I S = I$		speech rate -	0.36		0.41	
	Jitt. =	Jitter, Shim. = Shimmer,	ΔΙς	ΔI S-F		

**Control** Control

ALS-E

Harmonic/Noise Ratio, ZCR = Zero-Crossing Rate, Fo = Fundamental frequency

Classification models could distinguish ALS from control, and early ALS from control well (AUROC > 0.70).

Models were not significantly impacted by sex as a covariate (COV).

#### Conclusions

Automated acoustic analysis using a remote-capable pipeline could detect bulbar ALS, as well as earlier stages of the disease.

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- These results show that speech can support future efforts to stratify ALS patients for clinical trials.
- Future work will address this, along with evaluating performance across a greater range of severities.

