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Gradient boosting approaches can outperform logistic regression for risk prediction in cutaneous allergy

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Abstract

Background

Contact allergy is a major clinical and public health challenge. It is important to identify individuals who are at risk and perform patch testing to identify relevant allergens. Predicting clinical risk on the basis of input parameters is common in clinical medicine and traditionally has been achieved with linear models.

Objectives

We hypothesised that the risk of a clinically-relevant positive patch test could be predicted according to clinical and demographic parameters.

Methods

We compared the predictive accuracy of logistic regression to more sophisticated machine learning approaches such as gradient boosting, in the prediction of patch testing results.

Results

We found that both logistic regression and more sophisticated machine learning approaches were able to predict the risk of positive patch tests. For certain predictions,

including the overall risk of a clinically-relevant positive patch test, gradient boosting approaches can outperform logistic regression.

Conclusions

These findings suggest that complex non-linear interactions between input variables are relevant in risk prediction. Whilst a risk prediction model cannot replace the judgement of an experienced clinician, quantifying the risk of a clinically-relevant positive patch test result has the potential to assist in decision making and to inform discussions with patients.

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TITLE PAGE

Gradient boosting approaches can outperform logistic regression for risk prediction in cutaneous allergy

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SUPPLEMENTARY DATA

Supplementary Figure Legends

Supplementary Figure 1

A) Comparison of the performance of the logistic regression model where all variables are included versus the included 'allergy_now_all', 'one_pos_all' versus only statistically significant variables 'allergy_now_sig', 'one_pos_sig'. Results are presented as mean +/- S.D. for 4-folds. There is no statistically significant difference.

B-E) Comparison of the performance of the logistic regression and gradient boosting classifiers with the train and test cases split according to date of testing rather than randomly. Training data (blue line) was up to 2010 and test data (orange line) in and after 2010.

Supplementary Figure 2

Examples ROC and calibration curves for selected outcome variables

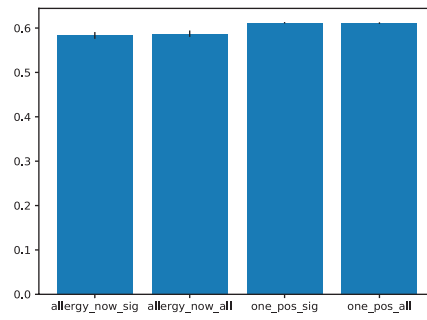
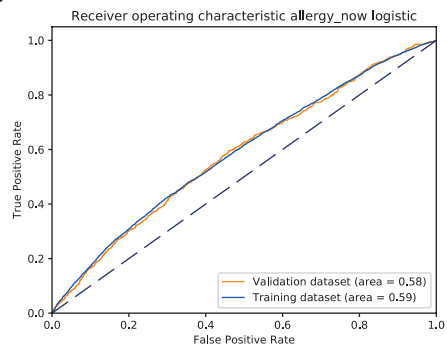
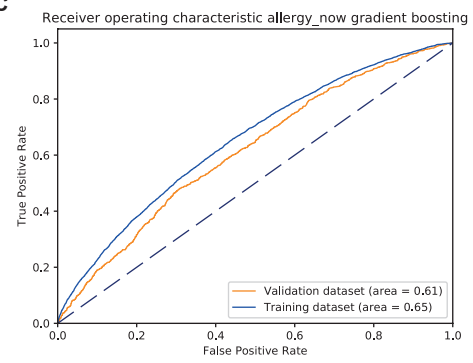
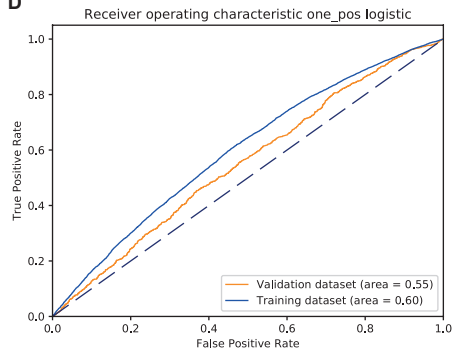
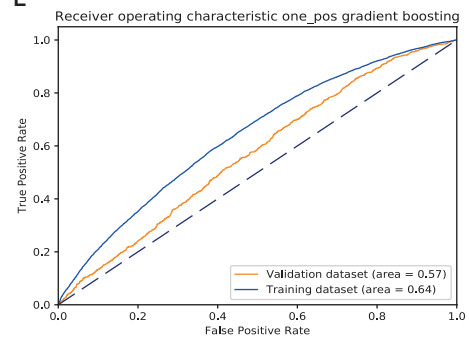
A-J) Receiver operating characteristic (ROC) curves for logistic regression (A, C, E, G, I) and gradient boosting (B, D, F, H, J) with selected outcome variables - sesquiterpene lactone (A, B); carba mix (C, D); Nickel (E, F); Epoxy resin (G, H); Imidazolidinyl urea (I,J). Input data was split into training (blue) test (orange) datasets.

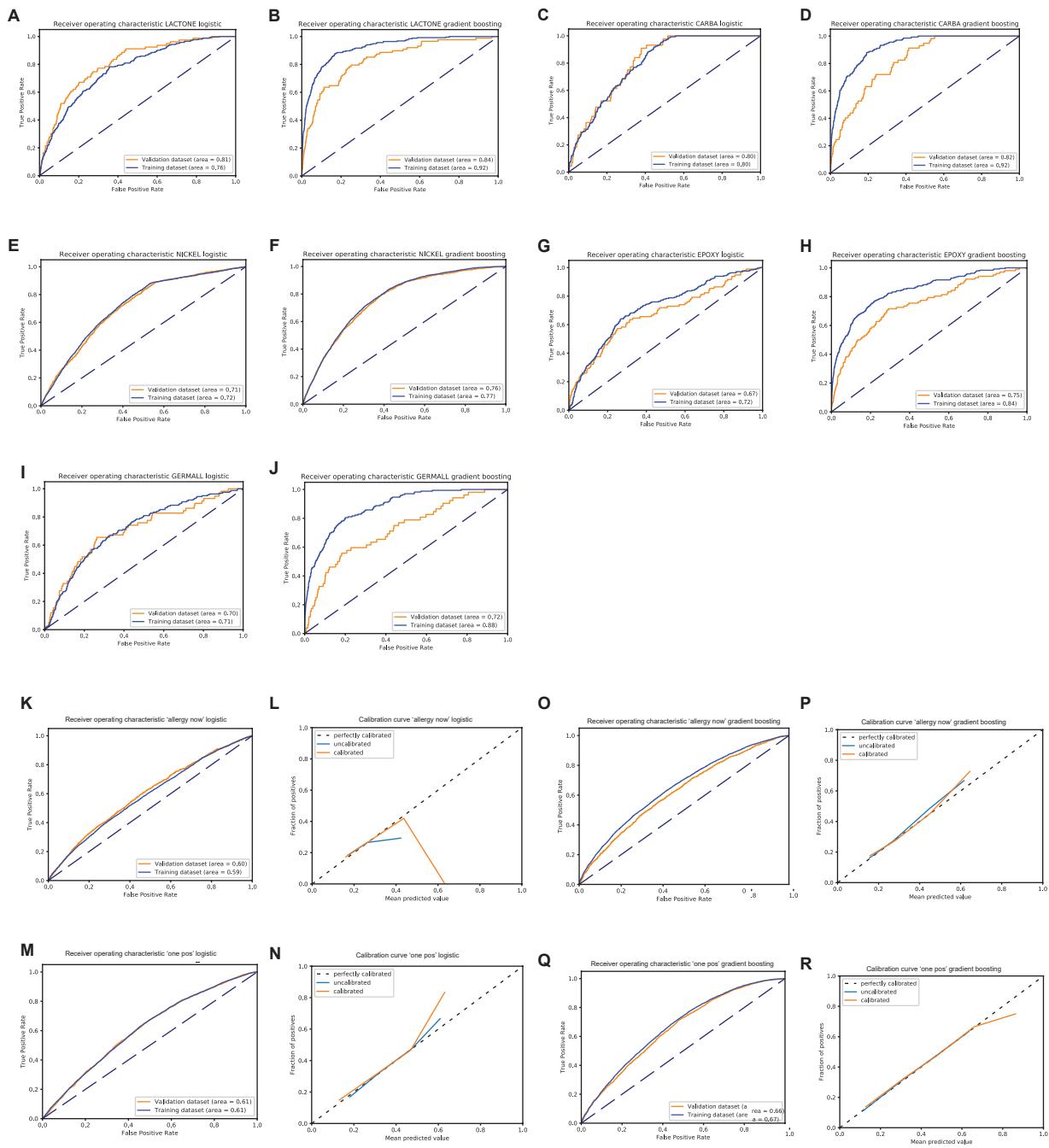
K-R) ROC curves and calibration curves for the prediction of current clinically relevant allergy 'allergy now' (K,L,O,P) and at least one positive patch test 'one pos' (M,N,Q,R) for logistic regression (K-N) and gradient boosting (O-R).

Calibration curves (L,N,P,R) illustrate the relationship between the numerical output of the classifier and the true risk of the outcome. The dashed line represents a perfectly calibrated classifier. The blue line illustrates the relationship between the output of the classifier and the true probability of the outcome. For comparison we have also plotted the output of the classifier after adjustment with the scikit-learn CalibratedClassifierCV class (orange).

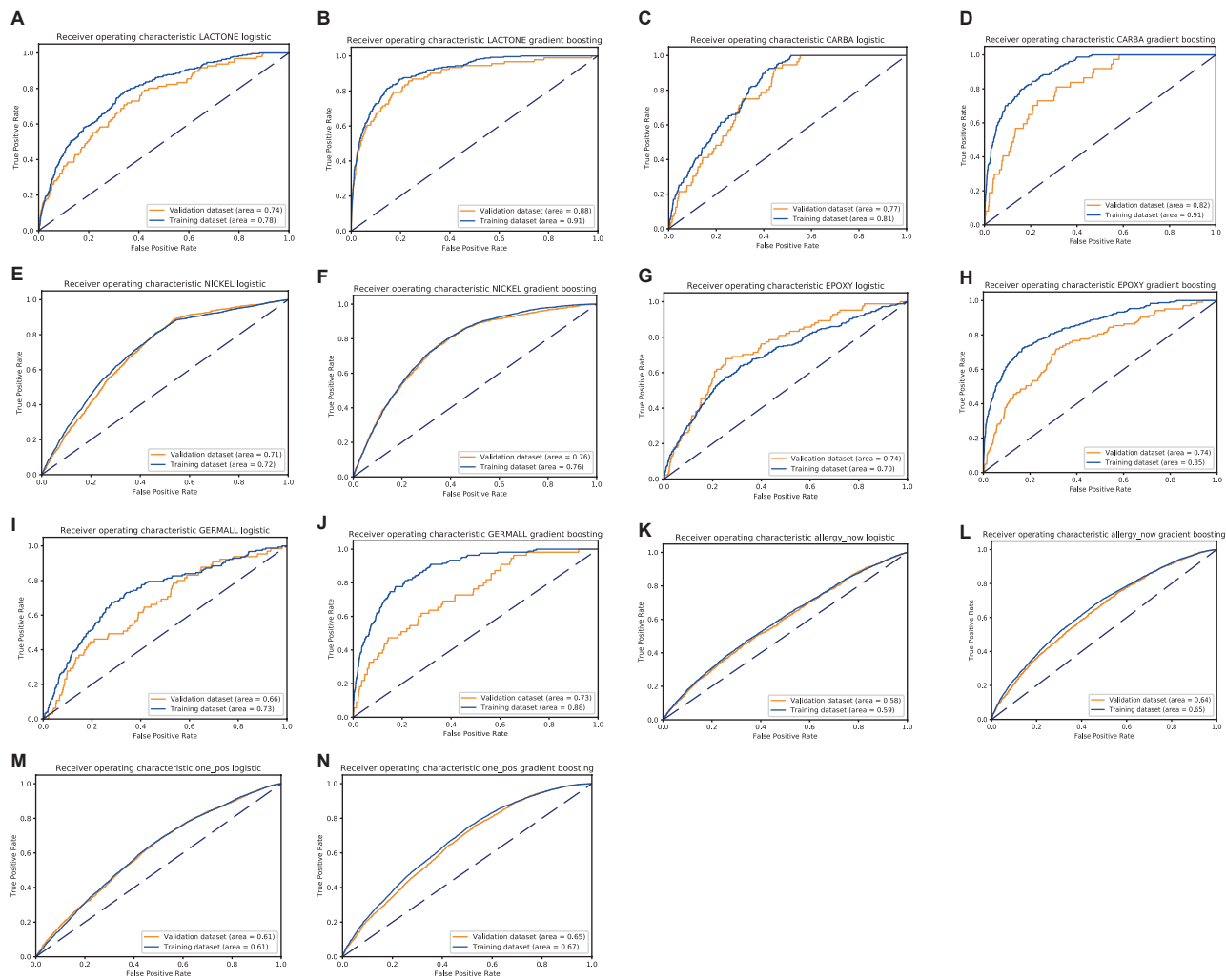
Supplementary Figure 3

Receiver operating characteristic (ROC) curves for a separate split of train versus test data to that presented in the main text.

A**B****C****D****E****Supplementary Figure 1**



Supplementary Figure 2



Supplementary Figure 3

Supplementary Tables

Supplementary Table 1: **Occupations in tested dataset**

Occupation	Number of patients
Office Work	10295
Retired	3919
Student	3554
Housewife	3444
Medical / Dental / Nurse / Vet	2365
Unemployed	1885
Catering	1325
Other	1309
Teacher	1060
Metal Handling	953
Salesperson	890
Domestic	802
Hairdresser / Beauty	691
Mechanical / Maintenance	664
Scientist / Lab	589
Transport	577
Paramedical	557
Builder / Construction	539
Service Industry	521
Electrician / Plumber	423

Arts / Crafts	335
Florist / Argic	326
Chemical Handling	317
Money Handler	280
Painting	274
Professor / English / Archaeology	272
Stores / Packer	265
Performer	252
Platics / Resins / Polymer / Glass Handling	244
Clothing / Textiles Handling	236
Food Handling	226
Supervisor	200
Carpenter / Joiner	195
Painter / Decorater	176
Wood / Paper Handling	171
Assembler	168
Photo / Tech	138
Military	123
Rubber Handling	58
Electroplating	21

Supplementary Table 2: Statistically significant associations identified by logistic regression analysis

Predicted	Parameter	Magnitude	Odds Ratio	CI lower	CI upper	P Value	Significant at Bonferonni cutoff?
allergy_now	age	0.014	1.015	1.0123	1.02	7.7E-37	*
allergy_now	sexM	-0.38	0.684	0.6356	0.74	4.5E-24	*
allergy_now	date	-0.01	0.99	0.9868	0.99	2.3E-12	*
allergy_now	sitearm	0.315	1.37	1.0511	1.8	0.021	
allergy_now	siteaxilla	0.653	1.922	1.3235	2.79	0.00058	*
allergy_now	siteear_canal	0.374	1.454	1.0102	2.09	0.043	
allergy_now	siteface_neck	0.41	1.507	1.202	1.91	0.00048	*
allergy_now	siteflexures	-0.402	0.669	0.4642	0.96	0.029	
allergy_now	sitehand	0.239	1.269	1.0127	1.61	0.042	
allergy_now	sitehand_face	0.758	2.134	1.6416	2.79	2.1E-08	*
allergy_now	occupationarts_crafts	-0.567	0.567	0.3894	0.82	0.0029	
allergy_now	occupationcatering	-0.41	0.664	0.4984	0.89	0.0051	
allergy_now	occupationclothing_textiles_handling	-0.647	0.524	0.3467	0.78	0.0019	
allergy_now	occupationdomestic	-0.824	0.439	0.3208	0.6	2.4E-07	*
allergy_now	occupationelectrician_plumber	-0.855	0.425	0.2914	0.62	7.5E-06	*
allergy_now	occupationfood_handling	-0.698	0.498	0.3205	0.76	0.0016	

allergy_now	occupationhairdresser_beauty	0.318	1.374	1.0094	1.88	0.044	
allergy_now	occupationhousewife	-0.745	0.475	0.3611	0.63	1.1E-07	*
allergy_now	occupationmechanical_maintenance	-0.741	0.477	0.3431	0.66	9.3E-06	*
allergy_now	occupationmed_dent_nurse_vet	-0.502	0.606	0.4594	0.8	0.00039	*
allergy_now	occupationmetal_handling	-0.475	0.622	0.4622	0.84	0.0017	
allergy_now	occupationoffice_work	-0.661	0.516	0.3987	0.67	5.9E-07	*
allergy_now	occupationother	-0.545	0.58	0.4248	0.79	0.0006	*
allergy_now	occupationpainting	-0.425	0.654	0.4452	0.96	0.029	
allergy_now	occupationparamedical	-0.551	0.577	0.4081	0.81	0.0017	
allergy_now	occupationperformer	-0.625	0.535	0.3471	0.82	0.004	
allergy_now	occupationprofessor_english_archaeology	-0.897	0.408	0.2636	0.62	4.1E-05	*
allergy_now	occupationretired	-0.756	0.469	0.3573	0.62	6E-08	*
allergy_now	occupationsalesperson	-0.731	0.481	0.3533	0.66	3.6E-06	*
allergy_now	occupationscientist_lab	-0.373	0.689	0.4977	0.95	0.025	
allergy_now	occupationservice_industry	-0.79	0.454	0.3207	0.64	7.5E-06	*
allergy_now	occupationstores_packer	-0.668	0.513	0.3364	0.77	0.0016	
allergy_now	occupationstudent	-0.662	0.516	0.3891	0.68	4.3E-06	*
allergy_now	occupationsupervisor	-0.495	0.61	0.3905	0.94	0.027	
allergy_now	occupationteacher	-0.732	0.481	0.3542	0.65	2.9E-06	*
allergy_now	occupationtransport	-0.879	0.415	0.2943	0.58	5E-07	*

allergy_now	occupationunemployed	-0.763	0.466	0.3492	0.62	2.4E-07	*
allergy_now	occupationwood_paper_handling	-0.949	0.387	0.2352	0.62	0.00013	*
allergy_now	duration1_to_6_months	0.174	1.19	1.0942	1.29	4.7E-05	*
allergy_now	duration6_months_to_year	0.121	1.128	1.0426	1.22	0.0027	
allergy_now	durationless_month	0.309	1.362	1.1371	1.63	0.00072	
allergy_now	durationmore_5_years	0.103	1.108	1.033	1.19	0.0042	
allergy_now	spreadY	0.337	1.4	1.3216	1.48	4E-30	*
allergy_now	atopyY	-0.099	0.906	0.8467	0.97	0.0038	
one_pos	age	0.011	1.011	1.009	1.01	8.4E-26	*
one_pos	sexM	-0.67	0.512	0.4786	0.55	1.4E-85	*
one_pos	date	-0.023	0.977	0.9744	0.98	4.7E-67	*
one_pos	siteflexures	-0.333	0.717	0.5322	0.96	0.028	
one_pos	sitehand_face	0.42	1.521	1.2006	1.93	0.00054	*
one_pos	occupationbuilder_construction	0.475	1.608	1.1701	2.21	0.0034	
one_pos	occupationprofessor_english_archaeology	-0.475	0.622	0.4159	0.92	0.019	
one_pos	occupationstudent	-0.285	0.752	0.5711	0.99	0.043	
one_pos	durationmore_5_years	0.117	1.124	1.0549	1.2	0.00031	*
one_pos	spreadY	0.205	1.227	1.1631	1.3	8.5E-14	*
one_pos	atopyY	-0.141	0.869	0.8176	0.92	5.7E-06	*
one_pos	houseworksome_regularity	0.12	1.127	1.0248	1.24	0.014	

Sesquiterpene lactone	age	0.049	1.05	1.0361	1.07	3.4E-12	*
Sesquiterpene lactone	sexM	0.629	1.875	1.1757	3.01	0.0086	
Sesquiterpene lactone	date	0.31	1.364	1.3264	1.41	2.7E-99	*
Sesquiterpene lactone	occupationcatering	-2.024	0.132	0.0287	0.47	0.0038	
Sesquiterpene lactone	occupationdomestic	-1.466	0.231	0.0629	0.74	0.018	
Sesquiterpene lactone	occupationhousewife	-1.261	0.283	0.1228	0.68	0.0037	
Sesquiterpene lactone	occupationmechanical_maintenance	-2.416	0.089	0.0144	0.39	0.0033	
Sesquiterpene lactone	occupationmed_dent_nurse_vet	-1.423	0.241	0.0687	0.76	0.019	
Sesquiterpene lactone	occupationmetal_handling	-2.355	0.095	0.019	0.36	0.0012	
Sesquiterpene lactone	occupationoffice_work	-2.169	0.114	0.048	0.28	1.1E-06	*
Sesquiterpene lactone	occupationother	-2.329	0.097	0.0201	0.39	0.0018	
Sesquiterpene lactone	occupationpainting	-2.154	0.116	0.0132	0.59	0.022	
Sesquiterpene lactone	occupationretired	-1.301	0.272	0.1225	0.63	0.0019	
Sesquiterpene lactone	occupationsalesperson	-2.218	0.109	0.0163	0.49	0.0091	
Sesquiterpene lactone	occupationstudent	-2.002	0.135	0.0333	0.51	0.0039	
Sesquiterpene lactone	occupationtransport	-2.433	0.088	0.0169	0.38	0.0021	
Sesquiterpene lactone	occupationunemployed	-1.652	0.192	0.056	0.61	0.0066	
Sesquiterpene lactone	duration6_months_to_year	-0.703	0.495	0.2578	0.91	0.028	
Sesquiterpene lactone	durationmore_5_years	0.662	1.939	1.3302	2.86	0.00067	
Sesquiterpene lactone	spreadY	0.661	1.937	1.3829	2.72	0.00013	*

Sesquiterpene lactone	houseworkno_housework	-0.957	0.384	0.198	0.74	0.0043	
Carba mix	age	0.033	1.034	1.0162	1.05	0.00017	*
Carba mix	date	-0.802	0.448	0.4123	0.48	3.5E-85	*
Carba mix	occupationelectroplating	4.344	77.052	1.4885	2855.63	0.022	
Carba mix	occupationrubber_handling	3.923	50.528	3.5933	771.57	0.0033	
Carba mix	occupationscientist_lab	2.355	10.536	1.1228	132.09	0.049	
Carba mix	occupationunemployed	2.269	9.666	1.2353	109.07	0.045	
Carba mix	durationmore_5_years	0.661	1.936	1.1125	3.43	0.021	
Carba mix	spreadY	0.808	2.243	1.4351	3.54	0.00043	*
Nickel	sexM	-0.816	0.442	0.3054	0.64	1.5E-05	*
Nickel	date	-0.208	0.813	0.799	0.83	8.5E-137	*
Nickel	occupationpainter_decorater	-4.464	0.012	0.0011	0.13	0.00017	*
Nickel	duration1_to_6_months	0.696	2.006	1.2983	3.16	0.0021	
Epoxy resin	date	-0.061	0.941	0.9069	0.97	0.00093	
Epoxy resin	occupationbuilder_construction	2.499	12.173	1.0833	119.62	0.032	
Epoxy resin	occupationelectrician_plumber	3.082	21.799	1.273	676.15	0.04	
Epoxy resin	occupationmetal_handling	3.477	32.375	1.8994	1026.85	0.021	
Epoxy resin	occupationplast_res_poly_glass_handling	3.671	39.295	2.3322	1185.1	0.013	
Epoxy resin	duration1_to_6_months	1.481	4.397	1.6616	12.66	0.004	
Epoxy resin	spreadY	0.752	2.122	1.0959	4.18	0.027	

Epoxy resin	psoriasisY	-1.117	0.327	0.1107	0.95	0.041	
Diazolidinyl urea	age	0.068	1.071	1.0542	1.09	3.8E-17	*
Diazolidinyl urea	sexM	-0.762	0.467	0.2714	0.8	0.0056	
Diazolidinyl urea	date	0.217	1.243	1.208	1.28	2.3E-48	*

Supplementary Table 3: **Brier scores for calibration**

Target	Model	Mean	Standard deviation
Balsum of Peru	logistic	0.028	0.002
Balsum of Peru	adaboost	0.039	0.003
Balsum of Peru	random forest	0.033	0.002
Balsum of Peru	gradient boosting	0.028	0.002
2-bromo-2-nitropropane-1,3-diol	logistic	0.008	0.001
2-bromo-2-nitropropane-1,3-diol	adaboost	0.015	0.008
2-bromo-2-nitropropane-1,3-diol	random forest	0.009	0.001
2-bromo-2-nitropropane-1,3-diol	gradient boosting	0.008	0.001
Caine mix	logistic	0.01	0.001
Caine mix	adaboost	0.016	0.002
Caine mix	random forest	0.012	0.001
Caine mix	gradient boosting	0.01	0.001

Carba mix	logistic	0.01	0.002
Carba mix	adaboost	0.014	0.002
Carba mix	random forest	0.011	0.002
Carba mix	gradient boosting	0.01	0.002
Cetostearyl alcohol	logistic	0.003	0.001
Cetostearyl alcohol	adaboost	0.005	0
Cetostearyl alcohol	random forest	0.004	0
Cetostearyl alcohol	gradient boosting	0.003	0.001
Chlorocresol	logistic	0.002	0.001
Chlorocresol	adaboost	0.002	0.001
Chlorocresol	random forest	0.002	0.001
Chlorocresol	gradient boosting	0.002	0.001
Cobalt	logistic	0.054	0.002
Cobalt	adaboost	0.081	0.003
Cobalt	random forest	0.063	0.002
Cobalt	gradient boosting	0.053	0.002
Colophonium	logistic	0.039	0.001
Colophonium	adaboost	0.061	0.007
Colophonium	random forest	0.045	0.001
Colophonium	gradient boosting	0.039	0.001

Potassium dichromate	logistic	0.026	0.001
Potassium dichromate	adaboost	0.036	0.002
Potassium dichromate	random forest	0.029	0.001
Potassium dichromate	gradient boosting	0.025	0.001
Quaternium 15	logistic	0.019	0.003
Quaternium 15	adaboost	0.032	0.003
Quaternium 15	random forest	0.022	0.002
Quaternium 15	gradient boosting	0.019	0.003
Epoxy resin	logistic	0.01	0.001
Epoxy resin	adaboost	0.014	0.001
Epoxy resin	random forest	0.012	0.001
Epoxy resin	gradient boosting	0.01	0.001
Ethylenediamine	logistic	0.012	0.001
Ethylenediamine	adaboost	0.024	0.004
Ethylenediamine	random forest	0.014	0.001
Ethylenediamine	gradient boosting	0.012	0.001
Methyldibromoglutaronitrile	logistic	0.012	0.001
Methyldibromoglutaronitrile	adaboost	0.015	0.001
Methyldibromoglutaronitrile	random forest	0.013	0.002
Methyldibromoglutaronitrile	gradient boosting	0.012	0.001

Fragrance mix 2	logistic	0.015	0.002
Fragrance mix 2	adaboost	0.024	0.004
Fragrance mix 2	random forest	0.017	0.002
Fragrance mix 2	gradient boosting	0.015	0.002
Formaldehyde	logistic	0.024	0
Formaldehyde	adaboost	0.037	0.005
Formaldehyde	random forest	0.027	0
Formaldehyde	gradient boosting	0.024	0
Imidizalidinyl urea	logistic	0.008	0.001
Imidizalidinyl urea	adaboost	0.013	0.003
Imidizalidinyl urea	random forest	0.009	0.001
Imidizalidinyl urea	gradient boosting	0.008	0.001
Diazolidinyl urea	logistic	0.009	0
Diazolidinyl urea	adaboost	0.014	0.002
Diazolidinyl urea	random forest	0.01	0.001
Diazolidinyl urea	gradient boosting	0.009	0
MI / MCI	logistic	0.013	0.002
MI / MCI	adaboost	0.019	0.002
MI / MCI	random forest	0.015	0.001
MI / MCI	gradient boosting	0.013	0.002

Sesquiterpene lactone	logistic	0.014	0.002
Sesquiterpene lactone	adaboost	0.018	0.004
Sesquiterpene lactone	random forest	0.015	0.002
Sesquiterpene lactone	gradient boosting	0.013	0.002
Mercaptobenzothiazole	logistic	0.009	0
Mercaptobenzothiazole	adaboost	0.013	0.001
Mercaptobenzothiazole	random forest	0.011	0.001
Mercaptobenzothiazole	gradient boosting	0.009	0.001
Mercapto mix	logistic	0.008	0.001
Mercapto mix	adaboost	0.013	0.002
Mercapto mix	random forest	0.01	0.001
Mercapto mix	gradient boosting	0.008	0.001
Methylisothiazolinone	logistic	0.028	0.006
Methylisothiazolinone	adaboost	0.043	0.005
Methylisothiazolinone	random forest	0.032	0.006
Methylisothiazolinone	gradient boosting	0.029	0.006
Neomycin	logistic	0.034	0.001
Neomycin	adaboost	0.049	0.002
Neomycin	random forest	0.039	0.001
Neomycin	gradient boosting	0.034	0.001

Nickel	logistic	0.127	0.001
Nickel	adaboost	0.163	0.002
Nickel	random forest	0.143	0.002
Nickel	gradient boosting	0.123	0.001
Paraben mix	logistic	0.006	0.001
Paraben mix	adaboost	0.014	0.011
Paraben mix	random forest	0.006	0.001
Paraben mix	gradient boosting	0.006	0.001
Fragrance mix 1	logistic	0.065	0.002
Fragrance mix 1	adaboost	0.093	0.005
Fragrance mix 1	random forest	0.075	0.002
Fragrance mix 1	gradient boosting	0.064	0.002
PPD	logistic	0.031	0.002
PPD	adaboost	0.04	0.002
PPD	random forest	0.034	0.002
PPD	gradient boosting	0.03	0.002
N-isopropyl-N-phenyl-PPD	logistic	0.004	0
N-isopropyl-N-phenyl-PPD	adaboost	0.007	0
N-isopropyl-N-phenyl-PPD	random forest	0.005	0
N-isopropyl-N-phenyl-PPD	gradient boosting	0.005	0.001

Primin	logistic	0.006	0
Primin	adaboost	0.013	0.004
Primin	random forest	0.007	0
Primin	gradient boosting	0.006	0
PTBP resin	logistic	0.009	0.001
PTBP resin	adaboost	0.039	0.027
PTBP resin	random forest	0.011	0.001
PTBP resin	gradient boosting	0.009	0.001
Quinoline	logistic	0.007	0.001
Quinoline	adaboost	0.025	0.026
Quinoline	random forest	0.008	0.001
Quinoline	gradient boosting	0.007	0.001
SODIUM METABISULFITE	logistic	0.012	0.002
SODIUM METABISULFITE	adaboost	0.029	0.024
SODIUM METABISULFITE	random forest	0.014	0.002
SODIUM METABISULFITE	gradient boosting	0.013	0.002
Thiuram mix	logistic	0.034	0.001
Thiuram mix	adaboost	0.051	0.005
Thiuram mix	random forest	0.038	0.001
Thiuram mix	gradient boosting	0.033	0.001

Tixocortol pivate	logistic	0.012	0.001
Tixocortol pivate	adaboost	0.016	0
Tixocortol pivate	random forest	0.014	0.001
Tixocortol pivate	gradient boosting	0.012	0.001
Lanolin	logistic	0.016	0.002
Lanolin	adaboost	0.055	0.025
Lanolin	random forest	0.018	0.001
Lanolin	gradient boosting	0.015	0.002
Disperse yellow 3	logistic	0.005	0
Disperse yellow 3	adaboost	0.008	0.001
Disperse yellow 3	random forest	0.006	0
Disperse yellow 3	gradient boosting	0.005	0
allergy_now	logistic	0.178	0.001
allergy_now	adaboost	0.228	0.001
allergy_now	random forest	0.2	0.003
allergy_now	gradient boosting	0.174	0.001
allergy_past	logistic	0.143	0.002
allergy_past	adaboost	0.188	0.004
allergy_past	random forest	0.165	0.003
allergy_past	gradient boosting	0.141	0.002

one_not_nickel	logistic	0.21	0.002
one_not_nickel	adaboost	0.256	0.004
one_not_nickel	random forest	0.236	0.003
one_not_nickel	gradient boosting	0.202	0.001
one_pos	logistic	0.23	0.001
one_pos	adaboost	0.276	0.005
one_pos	random forest	0.257	0.003
one_pos	gradient boosting	0.221	0.001

Supplementary Table 4: **Gini importance for Gradient Boosting classification**

Target	age_cat	date_cat	sex	site	occupation	duration	spread	atopy	psoriasis	housework	fh_atopy
Myroxylon Pereirae	0.37	0.15	0.03	0.15	0.12	0.05	0.01	0.05	0.02	0.03	0.01
2-bromo-2-nitropropane-1,3-diol	0.07	0.19	0.02	0.23	0.22	0.05	0.06	0.03	0.06	0.05	0.03
Caine mix	0.37	0.14	0.02	0.17	0.1	0.08	0.03	0.02	0.02	0.04	0.01
Carba mix	0.21	0.27	0.01	0.11	0.12	0.1	0.09	0.01	0.05	0.04	0
Cetostearyl alcohol	0.21	0.13	0.01	0.26	0.14	0.03	0.17	0.01	0.02	0.02	0.01
Chlorocresol	0.02	0.03	0.02	0.04	0.18	0.04	0.01	0	0.64	0.02	0.01
Cobalt	0.12	0.15	0.19	0.18	0.17	0.06	0.04	0.03	0	0.03	0.01
Colophonium	0.21	0.24	0.02	0.15	0.13	0.16	0.03	0.01	0.01	0.03	0.02

Potassium dichromate	0.03	0.07	0.05	0.29	0.38	0.1	0.05	0.01	0	0.01	0
Quaternium 15	0.03	0.26	0.11	0.17	0.25	0.05	0.04	0.03	0.01	0.05	0.02
Epoxy resin	0.07	0.08	0.08	0.09	0.55	0.03	0.04	0.04	0.01	0.01	0
Ethylenediamine	0.12	0.22	0.03	0.2	0.22	0.07	0.05	0.02	0.01	0.05	0.01
Methyldibromoglutaronitri le	0.1	0.24	0.01	0.19	0.2	0.04	0.05	0.05	0.05	0.05	0.01
Fragrance mix 2	0.13	0.13	0.03	0.19	0.18	0.19	0.01	0.03	0.02	0.05	0.02
Formaldehyde	0.04	0.17	0.07	0.16	0.33	0.07	0.05	0.03	0.01	0.04	0.02
Imidizalidiny l urea	0.24	0.24	0.04	0.21	0.07	0.06	0.02	0.02	0.02	0.05	0.03
Diazolidiny l urea	0.23	0.25	0.01	0.15	0.13	0.05	0.01	0.05	0.02	0.11	0
MI / MCI	0.06	0.41	0.02	0.19	0.17	0.04	0.03	0.01	0.01	0.05	0.01
Sesquiterpene lactone	0.29	0.09	0	0.18	0.14	0.13	0.11	0.01	0	0.05	0
Mercaptobenzothiazole	0.15	0.12	0.02	0.34	0.19	0.07	0.02	0.03	0.01	0.04	0.01
Mercapto mix	0.15	0.1	0.02	0.32	0.26	0.06	0.02	0.01	0.02	0.04	0.01
Methylisothiazolinone	0.03	0.35	0.03	0.16	0.13	0.11	0.01	0.01	0.04	0.09	0.02
Neomycin	0.32	0.25	0	0.28	0.07	0.02	0.02	0.01	0	0.04	0
Nickel	0.16	0.18	0.56	0.02	0.02	0.01	0	0.03	0	0.01	0
Parabens mix	0.24	0.09	0.02	0.19	0.23	0.11	0.04	0.01	0.01	0.05	0.02
Fragrance mix 1	0.34	0.24	0.07	0.09	0.11	0.07	0.02	0.01	0.01	0.02	0.01
PPD	0.16	0.14	0.04	0.17	0.38	0.03	0.03	0	0.01	0.04	0.01
N-isopropyl-N-phenyl-PPD	0.05	0.1	0.09	0.24	0.23	0.06	0.05	0.02	0.01	0.12	0.02
Primin	0.21	0.1	0.04	0.15	0.24	0.04	0.04	0.02	0.03	0.11	0.01

PTBP resin	0.06	0.24	0.02	0.12	0.25	0.12	0.04	0.02	0.03	0.06	0.03
Quinoline	0.26	0.18	0.05	0.21	0.18	0.03	0.03	0	0.01	0.04	0.01
SODIUM METABISULFITE	0.07	0.22	0.03	0.17	0.31	0.03	0.03	0.05	0.05	0.02	0.02
Thiuram mix	0.19	0.12	0.04	0.28	0.16	0.09	0.08	0.01	0	0.03	0
Tixocortol pivate	0.16	0.26	0.02	0.17	0.17	0.05	0.02	0.04	0.02	0.08	0.01
Lanolin	0.18	0.21	0.02	0.31	0.11	0.06	0.03	0.02	0	0.05	0.01
Disperse yellow 3	0.03	0.35	0	0.1	0.09	0.04	0.01	0.01	0	0.02	0.35
allergy_now	0.1	0.1	0.06	0.25	0.21	0.05	0.18	0.02	0	0.02	0
allergy_past	0.13	0.05	0.48	0.14	0.06	0.07	0.01	0.01	0	0.03	0.01
one_not_nickel	0.31	0.33	0.06	0.09	0.06	0.06	0.07	0.01	0	0.01	0
one_pos	0.12	0.41	0.23	0.07	0.04	0.05	0.04	0.03	0	0.01	0