

**Kai Zhao, Ph.D.**

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**A. EDUCATION AND APPOINTMENTS**

**Education**

2004	Ph.D.	University of Pennsylvania, Philadelphia, PA. (Bioengineering)
1999	M.S.E	University of Pennsylvania, Philadelphia, PA. (Bioengineering)
1996	B.S.	Zhejiang University, Hangzhou, China. (Biomedical Engineering)

**Positions**

2015-current	Associate Professor (with Tenure), Department of Otolaryngology - Head&Neck Sugery, the Ohio State University, Columbus, OH
2008-2015	Adjunct Assistant Professor of Otolaryngology, Thomas Jefferson University Medical College, Philadelphia, PA
2007-2014	Assistant Member, Monell Chemical Senses Center, Philadelphia, PA
2004-2007	Postdoctoral Fellow, Monell Chemical Senses Center, Philadelphia, PA

**Institutional appointments:**

2015-current	Director, Nasal Physiology and Therapeutic Center, Department of Otolaryngology – Head and Neck Surgery, The Ohio State University Medical Center
2020-current	Sanction committee, University Senate, The Ohio State University.
2020-current	Screeener, Medical student admission committee, The Ohio State University Medical Center
2022-current	Committee on Academic Misconduct, University Senate, The Ohio State University.
2018-current	Resident training committee, Department of Otolaryngology – Head and Neck Surgery
2018-current	Research committee, Department of Otolaryngology – Head and Neck Surgery
2016-2019	Faculty council, The Ohio State University Medical Center

**B. RESEARCH SUPPORT**

**Current research support**

“Towards Universal Chemosensory Testing”

Agency: **NIH-NIDCD, 1R13DC021114**, multi PIs: Valentina Parma, **Kai Zhao**, Mark Albers, Steven Munger (4/1/2023-3/31/2025, direct cost: \$40,000)

This project supports a new conference to be held on Nov 6-7 in Philadelphia to bring together scientists, clinicians, public health officials, patients and all other interested parties to identify opportunities and challenges for implementing routine chemosensory testing nationwide.

“Short-term and long-term impact of COVID-19 on multiple sensory systems”

Agency: **NIH-NIDCD, R01 DC020737, PI: Kai Zhao** (2/1/2023-2/1/2028, 5 year total cost \$2,597,150)

This research will extensively investigate and capture short-term and long-term COVID-associated multisensory dysfunctions spanning smell, taste, chemesthesis, hearing, and balance, their recovery, and their relationship with patients’ disease profiles, which will enable more comprehensive understanding to better support future patient care and recovery.

Zhao, Kai

“Novel treatment options for conductive olfactory losses & nasal obstruction symptoms”,

Agency: **NIH-NIDCD, R01DC020302 PI, PI: Kai Zhao** (9/27/2022-10/01/2027, 5 year total cost \$1,968,750)

The proposed study aims to develop novel clinical tools to better evaluate and relieve patients’ nasal obstructive symptoms (including smell losses) and to enable patients and clinicians to make more informed, personalized decisions regarding treatment strategy.

“Tissue-engineered trachea composites for long-segment airway replacement”

NIH-NHLBI 1R01HL157039-01, PI: Tandy Chiang (7/16/2021 – 6/30/2026)

Role: **subcontract PI** (10%, Annual total cost \$122,042)

This proposal addresses the barriers of tracheal collapse and SAE regeneration with the introduction of composite Tissue Engineered Tracheal Grafts.

### Pending research supports

“Optimizing topical drug delivery for personalized treatment of chronic rhinosinusitis”,

Agency: **NIH-NHLBI, R01, PI: Kai Zhao** (planning resubmission, 5 year total cost \$2,595,017)

### Completed research support

“A confectionary-based screening tool for assessing chemosensory loss in COVID-19 patients”

**NIH RADx-rad COVID-19 Initiative 3R01DC016112-04S1, PI: Susan Travers** (12/21/2020 – 012/20/2022, total cost \$305,085)

Role: Co-Investigator (20%) and 50% of a postdoc

The goals of this Emergency Competitive Revision are to develop (Aim 1) and deploy (Aim 2) a novel, objective, psychophysical smell and taste screening test based on hard candy to detect the onset of COVID 19 in at-risk populations.

“Noninvasive Nasal Aid to Improve Nasal Obstruction Symptoms”

Agency: **Ohio State Dept. of Education, Accelerator Awards, PI: Kai Zhao** (01/01/2020-12/31/2022, total direct cost \$150,000)

This project aims to develop and refine a novel nasal aid to relieve nasal obstruction symptoms.

“Sinonasal Visualization and Quantification of the Effect of Oxymetazoline Nasal Spray”

Agency: **Bayer, Inc., PI: Kai Zhao** (1 year total cost \$120,000)

To understand the effect of oxymetazoline nasal spray on nasal turbinates and nasal airway morphology, its impact on nasal aerodynamics and indication to guide surgery decision.

“Optimizing surgical outcomes to olfactory losses through endoscopic sinus surgery simulator” Agency:

**NIH-NIDCD R21 DC017530, PI: Kai Zhao** (3/01/2019-3/1/2022, total direct cost \$275,000)

This project proposed to develop and validate a virtual endoscopic sinus surgery simulator to simulate, predict, and optimize surgical approaches on air/odor flow to the olfactory fossa that may improve clinical practice and offer personalized medicine in the future.

“RELIEVA TRACT Balloon Dilation System: Preclinical Study”

Agency: Acclarent, Inc., PI: Alexander Farag (10/23/2019-6/30/2021, Total cost \$95,222)

Role: Co-Investigator

“Objective evaluation of conductive olfactory losses & nasal obstruction symptoms”,

Agency: **NIH-NIDCD, R01 DC013626, PI: Kai Zhao** (12/01/2014-11/31/2019, 4 year total cost \$1,523,000)

This project aims to objectively evaluate the conductive mechanisms contributing to nasal obstruction symptoms, including smell losses, by combining novel computational models with existing sensory measurements.

“Relieve nasal obstruction symptoms through modulation of airflow via a novel nasal plug”, Agency: Ohio Dept. of Higher Education, Ohio ICorp program, **PI: Kai Zhao** (4/1/2019-9/30/2019, \$15,000).

“A Prospective, Non-Randomized Study to Evaluate Treatment Outcome of Nasal Airway Obstruction Using the Aerin Medical Vivaer Stylus”,  
Agency: Industry Sponsor, Otto (PI) (5/19/17-5/19/19) Budget: \$192,250.53,  
Role: Co-Investigator

“Modulation of Olfactory Cilia” (05/01/2012-04/30/2016)  
Agency: **NIH NIDCD, R01** DC011554, PI: Minghong Ma (Neuroscience, UPENN)  
**Subcontract PI: Kai Zhao** (20%). This project investigates modulation of the structure and function of olfactory cilia, by the stimulus input properties in the nasal cavity

“VOC Odor Signature Modeling for Portable Sensing Platforms” (10/01/2013-04/30/2014)  
Agency: **US Air Force** (SBIR FA8650-13-M-6448, phase I), PI: Applied Nanotech, Inc., **Subcontract PI: Kai Zhao** (\$23,000, 6 months)

“Airborne Human Odorants: detection, dispersion and characterization”, **US Air Force, PIs: George Preti, Kai Zhao** (total \$130,000), 06/01/2011 – 08/31/2012.  
The project uses computational and experimental approaches to simulate and detect the dispersion of human body odor after they are volatilized into the air phase to aid the design of a successful body odor detection system at stand-off distances.

“Nasal airflow and odorant transport: a prerequisite for normal olfaction” (12/01/2006- 12/01/2010)  
Agency: **NIH/NIDCD R03** DC008187-01 **PI: Kai Zhao** (3 Yrs total direct cost \$150,000)  
This project uses computational fluid dynamic (CFD) modeling techniques to quantify the anatomy-dependent nasal airflow and odorant mucosal deposition patterns among healthy human subjects and to characterize their potential functional impact on human olfactory function.

“The left-right asymmetry in Parkinson disease development” (2011, 1 year), Agency: private source, **PI: Kai Zhao** \$20,000 total cost.

“Nasal airflow and odorant transport in healthy adult domestic cat” (10/01/2007-09/30/2008)  
Industry funding: Mars, Inc. - Petcare. **PI: Kai Zhao** (total \$104,000)

“Occupational exposure, inflammatory process and chemosensory function” (1/01/2005- 12/31/2010). Agency: **NIH/NIDCD P50** DC 006760 PI: Pamela Dalton  
Role in this project: **Co-investigator** Using computational models to evaluate the degree to which occupational exposure-induced deviations in nasal airflow patterns are predictive of alternations in olfactory sensitivity.

“Temporal integration in nasal lateralization” (10/01/06-10/01/10)  
Agency: **NIH/NIEHS R03** Principal Investigator: Paul Wise  
Role in this project: **Consultant**. To develop a mathematical model that characterizes the tradeoff between stimulus-duration and concentration in the detection of chemical irritation in the human nose based on transport of molecules through the mucosa.

## C. HONORS, AWARDS AND PROFESSIONAL EXPERIENCES

### Honors and Awards

2004	Best Poster Presentation, <b>1<sup>st</sup> Place Award</b> , American Rhinology Society annual meeting
2004	<b>Frances Davidson Award for best oral presentation</b> , American Academy of Otolaryngology-- Head and Neck Surgery, Pennsylvania annual meeting
2003	<b>Feature Presentation</b> , highlighted for press release, Association for chemoreception sciences ( <i>AchemS</i> ) annual meeting
2017	Dr. Chengyu Li, a postdoc fellow, was awarded the Association for Chemoreception Sciences ( <i>AchemS</i> ) 2017 Polak Young Investigator

- 2019 2nd prize of ASME (American Society of Mechanical Engineers) Flow Visualization Competition
- 2019 Dr. Zhenxing Wu, a postdoc fellow, was awarded the AchemS 2019 Polak Young Investigator.
- 2023 Top rated clinical oral presentations, American Rhinologic Society Annual meeting

### **Professional Experiences and Organization**

- Ad hoc reviewer for NIH study section (BCHI), 2018
- Ad hoc reviewer for NIH study section (BMIT-A), 2017, 2018
- Ad hoc reviewer for NIH study section (Communication Disorders Review Committee), 2016
- Ad hoc reviewer for NIH study section (ZDC1 X-61), 2016
- Ad hoc reviewer for NIH study section (ZDC1 SRB-K(20)), 2015
- Ad hoc reviewer for Air Force Office of Scientific Research (AFOSR), 2015

Program committee for *Beijing international meeting on research in taste and smell*, 2009

Journal editorial board: *Fluid Dynamics & Materials Processing*

Journal Reviewers:

1. General scientific journals: *PNAS*, *Scientific Reports*, *Journal of the Royal Society Interface*, *Plos One*.
2. Neuroscience and Sensory Science journals: *Neuroscience*, *Chemical Senses*, *Chemoperception*, *Journal of Experimental Biology*, *Anatomical Record*, *Attention Perception Psychophysics*, *Journal of Food Engineering*, *Physiology Behavior*
3. Clinical journals: *Jama Facial plastic surgery*, *Laryngoscope*, *Otolaryngology Head&Neck surgery*, *American Journal of Rhinology*, *International Forum of Rhinology and Allergy*, *Clinical Otolaryngology*, *European Archives of Oto-Rhino-Laryngology*, *Acta Oto-laryngologica*, *Journal of Rhinology*, *Laryngoscope Investigative Otolaryngology*, *Surgery Research and Practice*, *Orthodontics and Craniofacial Research*, *Current Medical Imaging Reviews*, *BMC medical research method*, *International Journal of Computer Assisted Radiology and Surgery*, *Facial Plastic Surgery Aesthetic Medicine*, *Respiratory Physiology Neurobiology*, *World Journal of Otorhinolaryngology-Head and Neck Surgery*
4. Environmental Sciences: *Inhalation Toxicology*, *Journal of Aerosol Science*, *Science of the Total Environment*, *International Journal of Environmental Research and Public Health*, *Journal of Hazardous Materials*
5. Computational and Engineering journals: *Plos Comp. Biol.*, *Medical Engineering & Physics*, *Medical & Biological Engineering & Computing*, *Journal of Biomechanical Engineering*, *Journal of biomechanics*, *Computer Methods in Biomechanics and Biomedical Engineering*, *Computers in Biology and Medicine*, *Engineering computations*, *International Journal for Numerical Methods in Biomedical Engineering*, *Visual Computing for Industry Biomedicine and Art*, *Journal of Computational Science*, *IEEE Transactions on Medical Imaging*, *Fluid Dynamics & Materials Processing*, *International Journal of Nonlinear Sciences and Numerical Simulation (IJNSNS)*, *Biomechanics and Modeling in Mechanobiology*, *Computational and Mathematical Methods in Medicine*, *Engineering Science and Technology an International Journal*, *Engineering computations*

Memberships: Association for Chemoreception Sciences (AchemS), Biomedical Engineering Society (BMES), American Rhinological Society (ARS)

### **D. LECTURES AND PUBLICATIONS**

For complete list:

[https://www.researchgate.net/profile/Kai\\_Zhao14/publications](https://www.researchgate.net/profile/Kai_Zhao14/publications)

[https://scholar.google.com/citations?hl=en&user=V1qXhSkAAAJ&view\\_op=list\\_works&sortby=pubdate](https://scholar.google.com/citations?hl=en&user=V1qXhSkAAAJ&view_op=list_works&sortby=pubdate)

**Peer-reviewed Publications****Selected highlights**

- 1) Man K, Simons CT, Mohamed-Osman A, Travers SP and **Zhao K.** (2022) Chemosensory losses in past and active likely Delta variant break-through COVID-19 cases, *Med (flagship medical journal by Cell Press, IF: 17)* Jul 8; 3(7): 450–451 doi:10.1016/j.medj.2022.05.004, PMC9108022
- 2) Li C., Dong H. and **Zhao K.** (2018) A balance between aerodynamic and olfactory performance during flight in *Drosophila*, *Nature Communications(IF: 16.6)* 9:3215. PMC6086917
- 3) Lewis R., Tian HK., Wang J., He JW., Jiang J., Chen XM., Yin WB., Connelly T., Ma LM., Yu CR., Pluznick, JP., Storm DR., Huang LQ., **Zhao K.**, and Ma M. (2015) An Olfactory Cilia Pattern in the Mammalian Nose Ensures High Sensitivity to Odors, *Current Biology (10.6)*, Oct; 25(19):2503-12. PMC4596779
- 4) Scott JW\*, Sherrilla L., Jiang J., **Zhao K.\*** (2014) Tuning to Odor Solubility and Sorption Pattern in Olfactory Epithelial Responses, *Journal of Neuroscience (IF: 6.7)*, 34(6):2025-36, PMC3913860, \*co-first author

**Complete list**

- 5) Root Z.T., Lepley J.T., Wu Z., Chapman R., Schneller A., Formanek V.L., Kelly K.M., Otto B.A., **Zhao K.** (2023) How does oxymetazoline change nasal aerodynamics and symptomatology in patients with turbinate hypertrophy? *Laryngoscope*, doi.org /10.1002/lary.30968
- 6) Yan X, Menzel S., **Zhao K.**, Kim K., Hummel T. (2023) Intranasal trigeminal sensitivity to mechanical stimuli is associated with the perception of nasal patency, *European Archives of Oto-Rhino-Laryngology*, (in press)
- 7) Wu Z., Jiang J., Lischka S.F., McGrane S.J., Porat-Mesenco Y., **Zhao K.** (2023), Domestic cat nose functions as a highly efficient coiled parallel Gas Chromatograph, *Plos Computational Biology* 19(6): e1011119. doi.org/10.1371/journal.pcbi.1011119
- 8) Lepley J.T., Kim K., Ardizzone M., Kelly K., Otto B.A., **Zhao K.** (2023) 3D Printing as a planning tool to optimize sinonasal irrigation, *Annals of Otolaryngology, Rhinology & Laryngology* Jan 26;:34894221149242. doi: 10.1177/00034894221149242.
- 9) Spector B.M., Shusterman D.J., **Zhao K.** (2022) Nasal nitric oxide flux from the paranasal sinuses, *Curr Opin Allergy Clin Immunol.* Feb 1;23(1):22-28. doi:10.1097/ACI.0000000000000871. PMC10170969.
- 10) Kim K., **Zhao K.** (2022) A Nasal Aerodynamics Perspective of Retronasal Olfaction: Rodents vs. Humans, *Chemosensory Perception* Oct;15(2):124-134. doi: 10.1007/s12078-022-09300-2. PMC10168102.
- 11) Lepley J.T., Wu Z., Root Z., Chapman R., Schneller A., Otto B.A., Kelly K., **Zhao K.** (2022) Can oxymetazoline simulate outcomes of septoplasty and inferior turbinate reduction surgery?, *International Forum of Allergy Rhinol.* (in press). doi.org/10.1002/alr.23094

- 12) Lepley J.T., Wu Z., Root Z., Mountain D., Otto B.A., Kelly K., **Zhao K.** (2022) Computational fluid dynamic modeling of the effect of dupilumab in the management of anosmia secondary to CRSwNP, *International Forum of Allergy Rhinol.*, DOI: 10.1002/alr.23050
- 13) Lepley J.T., Frusciante R.P., Farag A.A., Malik J., Otto B.A., **Zhao K.** (2022) Otolaryngologists' radiological assessment of nasal septum deviation symptomatology, *European Archives of Oto-Rhino-Laryngology*, doi.org/10.1007/s00405-022-07528-y
- 14) Liu L, Sayali S, Spector BM, Agarwal R, Van Curen CE, Nyirjesy S, Shontz K, Tan ZH, Sperber SA, Breuer CK, **Zhao K.**, Reynolds SD, VanKoeveering KK, Chiang T. (2022) Tissue-engineered composite tracheal grafts create mechanically stable and biocompatible airway replacements, *Journal of Tissue Engineering*, doi.org/10.1177/20417314221108791
- 15) Malik J., Otto B.A., **Zhao K.** (2022) Computational Fluid Dynamics (CFD) Modeling as an Objective Analytical Tool for Nasal/Upper Airway Breathing, *Current Otorhinolaryngology Reports* 10, p116–120, 10.1007/s40136-021-00387-x
- 16) Brooks Z., Kim K., **Zhao K.**, Goswami T., Hussain S., Dixon AR. (2022) 3D printed transwell-integrated nose-on-chip model to evaluate effects of air flow-induced mechanical stresses on mucous secretion, *Biomedical Microdevices* 24, 8, doi.org/10.1007/s10544-021-00602-y
- 17) Miles B.L., Wu Z., Kennedy K.S., **Zhao K.**, Simons C.T. (2022) Elucidation of a lingual detection mechanism for high-viscosity solutions in humans, *Food & Function*, 13(1), 64–75 doi.org/10.1039/D1FO02460D, PMC8727634
- 18) Shusterman D.J., Spector B.M., Goldberg A.N., Weaver E.M., Otto B.A., **Zhao K.** (2022) Use of computational fluid dynamics (CFD) to model observed nasal nitric oxide levels in human subjects, *International Forum of Allergy Rhinol* May;12(5):735-743. DOI: 10.1002/alr.22913, PMC9050868 (\*journal cover)
- 19) Spector B.M., Shusterman D.J., Goldberg A.N., Weaver E.M., Farag A.A., Otto B.A., **Zhao K.** (2021) Computational modeling of nasal nitric oxide flux from the paranasal sinuses: validation against human experiment, *Computers in Biology and Medicine*, Sep;136:104723, doi: 10.1016/j.combiomed.2021.104723, PMC8440472
- 20) Mason E.C., Wu Z., McGheel S., Markley J, Koenigs M., Onwuka A., Chiang T., **Zhao K.** (2021) Computational fluid dynamic modeling reveals non-linear airway stress during trachea development , *Journal of Pediatrics*, Nov;238:324-328.e1. doi: 10.1016/j.jpeds.2021.07.038. PMC8551055
- 21) Malik J., Spector BM., Wu Z., Markley J., Zhao S., Farag A.A., Otto B.A., **Zhao K.** (2021) Evidence of nasal cooling and sensory impairments driving patient symptoms with septal deviation, *Laryngoscope*,132(3):509-517. doi.org/10.1002/lary.29673, PMC8669045
- 22) Wu Z., **Zhao K.** (2021) Impact of pulsation rate and viscosity on taste perception – application of a porous medium model for human tongue surface, *Computers in Biology and Medicine* Jul;134:104419, doi.org/10.1016/j.combiomed.2021.104419, PMC8263469
- 23) Liu L, Sayali Dharmadhikari S, Shontz KM, Tan ZH, Spector BM, Manning A, **Zhao K.**, Reynolds SD, Breuer CK, Chiang T. (2021) Regeneration of partially decellularized tracheal scaffolds in a mouse model of orthotopic tracheal replacement, *Journal of Tissue Engineering* (in press). doi: 10.1177/20417314211017417.
- 24) Choiński M, Gawron N, Pluta A, Sobańska M, Egbert AR, Bieńkowski P, Sienkiewicz-Jarosz H, Ścińska-Bieńkowska A, Szymańska B, Horban A, Firląg-Burkacka E, Wolak T, Rusiniak M, Bornstein R, **Zhao K.**, Łojek F. (2021) On the relationship between olfactory sensitivity and personality in

- 25) Malik J., Dholakia S., Spector BM., Yang A., Kim D., Borchard NA., Thamboo A., **Zhao K.\***, Nayak JV. (2021) Inferior meatus augmentation procedure (IMAP) normalizes nasal airflow patterns in empty nose syndrome patients via computational fluid dynamics (CFD) modeling, *International Forum of Allergy Rhinol*, 11(5):902-909. doi:10.1002/alr.22720, PMC1636956 (\*corresponding)
- 26) Kim K., Otto B.A., Farag A.A., **Zhao K.** (2021) Topical irrigation against gravity may lead to better sinus penetration, *International Forum of Allergy Rhinol*, Feb;11(2):198-200. doi: 10.1002/alr.22711 PMC1636084.
- 27) Wu Z., Krebs J.P., Spector B.M., Otto B.A., **Zhao K.\***, Farag A.A (2021) Regional peak mucosal cooling predicts radiofrequency treatment outcomes of nasal valve obstruction, *Laryngoscope*, 131(6): E1760-E1769. doi: 10.1002/lary.29223. (\*corresponding)
- 28) Wu Z. and **Zhao K.** (2020) Taste of time: a porous-medium model for human tongue surface with implications for early taste perception, *Plos Computational Biology*, 16(6): e1007888. doi: 10.1371/journal.pcbi.1007888. PMC7271999
- 29) Turfe Z., **Zhao K.**, Palmer J. and Craig J. (2020) Computational fluid dynamic modeling of maxillary sinus irrigation after maxillary antrostomy and modified endoscopic medial maxillectomy, *Journal of Laryngology and Otolaryngology*, doi.org/10.1017/S0022215121000013 (in press).
- 30) Li C., Dong H., and **Zhao K.** (2020) Dual functions of insect wings in an odor-guided aeronautic navigation, *Journal of Fluids Engineering* 142(3), 030902. doi.10.1115/1.4045946. PMC7104757
- 31) **Zhao K.**, Kim K., Craig JR., Palmer JN. (2020) Using 3D printed sinonasal models to visualize and optimize personalized sinonasal sinus irrigation strategies, *Rhinology*, 58: 3, 266 - 272, doi.org/10.4193/Rhin19.314. PMC1635361
- 32) Malik J., Thamboo A., Dholakia S., Borchard NA., McGhee S., Li C., **Zhao K.\***, Nayak JV. (2020) The cotton test redistributes nasal airflow in patients with empty nose syndrome, *International Forum of Allergy Rhinol* , Apr;10(4):539-545, DOI: 10.1002/alr.22489. PMC7182493. (journal cover, \*corresponding)
- 33) Wu Z., Craig JR., Maza G., Li C., Otto BA., Farag AA., Carrau RL., **Zhao K.** (2020) Peak sinus pressures during sneezing in healthy controls and post-skull base surgery patients, *Laryngoscope*, 130(9): 2138-2143. doi:10.1002/lary.28400. PMC7549275. (\*journal cover)
- 34) Malik J., Li C., Maza G., Farag A.A., Krebs J.P., McGhee S., Zappitelli G., Deshpande B., Otto B.A., **Zhao K.** (2019) Computational Fluid Dynamic analysis of aggressive turbinate reductions: Is it a culprit of Empty Nose Syndrome?, *International Forum of Allergy Rhinol*, 9(8):891-899. doi: 10.1002/alr.22350. PMC6687526
- 35) Li C., Maza G., Farag A.A., Krebs J.P., Deshpande B., Otto B.A., **Zhao K.** (2019) Asymptomatic vs. symptomatic septal perforations: A computational fluid dynamics examination, *International Forum of Allergy Rhinol*, 9(8):883-890. doi: 10.1002/alr.22337. PMC6750740
- 36) Mason E.C., McGhee S., **Zhao K.**, Chiang T., Matrkla L. (2019) The application of computational fluid dynamics in the evaluation of laryngotracheal pathology, *Annals of otology rhinology & laryngology*, May 128(5):453-459. doi: 10.1177/0003489419826601. PMC6753835

- 37) Alam S., Li C., Bradburn K.H., **Zhao K.**, Lee T.S. (2019) Impact of middle turbinectomy on airflow to the olfactory cleft: A computational fluid dynamics study, *American J of Rhinology and Allergy*, May 33(3):263-268. doi: 10.1177/1945892418816841. PMID: PMC6535904
- 38) Maza G., Li C., Krebs J.P., Otto B.A., Farag A.A., Carrau R.L., **Zhao K.** (2019) Computational fluid dynamics after endoscopic endonasal skull base surgery - possible ENS in the context of middle turbinate resection, *International Forum of Allergy Rhinol* Feb; 9(2):204-211. doi: 10.1002/alr.22236. PMID: PMC6358472
- 39) Eichaker L., Li C., King N., Pepper V., Best C., Onwuka E., Heuer E., **Zhao K.**, Grischkan J., Breuer C., Johnson J., Chiang T. (2018) Quantification of tissue engineered trachea performance with computational fluid dynamics, *Laryngoscope* 128(8): E272-E279 PMID: PMC6119110
- 40) Patel T., Li C., Krebs J., **Zhao K.**, Malhotra P. (2018) Modeling Congenital Nasal Pyriform Aperture Stenosis Using Computational Fluid Dynamics, *International Journal of Pediatric Otorhinolaryngology*, 109, 180-184, doi.org/10.1016/j.ijporl.2018.04.002, PMID: PMC5942217
- 41) Li C., Jiang J., Kim K., Otto B.A., Farag A.A., Cowart B.J., Pribitkin E.A., Dalton P., **Zhao K.**, (2018) Nasal structural and aerodynamic features that may benefit normal olfactory sensitivity, *Chemical Senses* 43(4), 229-237, PMID: PMC5913651
- 42) Lee TS., Goyal P., Li C., **Zhao K.**, (2018) Computational Fluid Dynamics to Evaluate the Effectiveness of Inferior Turbinate Reduction Techniques to Improve Nasal Airflow, *JAMA Facial Plastic Surgery*, 20(4):263-270 doi: 10.1001/jamafacial.2017.2296. PMID: PMC5872907
- 43) Li C., Farag A.A., Maza G., McGheel S., Ciccone M.A., Deshpande B., Pribitkin E.A., Otto B.A., **Zhao K.** (2017) Investigation of the abnormal nasal aerodynamics and trigeminal functions among empty nose syndrome patients, *International Forum of Allergy Rhinol*, 8(3), 444-452 doi: 10.1002/alr.22045. PMID: PMC6015742
- 44) Li C., Jiang J., Dong H. and **Zhao K.** (2017) Computational modeling and validation of human nasal airflow under various breathing conditions, *Journal of Biomechanics*, 64:59-68. doi: 10.1016/j.jbiomech.2017.08.031. PMID: PMC5694356
- 45) Shen J., Hur K., Li C., **Zhao K.**, Leopold D.A., Wrobel B.B. (2017) Determinants and Evaluation of Nasal Airflow Perception, *Facial Plast Surg*. Aug;33(4):372-377
- 46) Otto B.A., Li C., Farag A.A, Bush B., Krebs J., Hutcheson R., Kim K, and **Zhao K.** (2017) Computational fluid dynamics evidence of posterior septectomy as viable treatment option for large septal perforation, *International Forum of Allergy and Rhinology*, Jul;7(7):718-725. PMID: PMC5654740
- 47) Craig J., Palmer J. and **Zhao K.** (2017) Computational fluid dynamic modeling of nose-to-ceiling head positioning for sphenoid sinus irrigation, *International Forum of Allergy Rhinol*, May;7(5):474-479. doi: 10.1002/alr.21908 PMID: PMC5426973
- 48) Li C., Farag A.A., Leach J., Deshpande B., Jacobowitz A., Kim K., Otto B.A., **Zhao K.** (2017) Computational fluid dynamics and trigeminal sensory examinations of empty nose syndrome patients, *Laryngoscope*, Mar 9. doi: 10.1002/lary.26530 PMID: PMC5445013
- 49) Craig J., **Zhao K.**, Doan N., Khalili S., John LYK, Adappa ND and Palmer J. (2016) Cadaveric validation study of computational fluid dynamics model of sinus irrigations before and after sinus surgery, *International Forum of Allergy Rhinol* Apr;6(4):423-8. doi: 10.1002/alr.21677. PMID: PMC5145305  
(\*journal cover)



- 50) **Zhao K.**, Craig J., Cohen NA., Adappa ND, Khalili S. and Palmer J. (2016) Sinus irrigations before and after surgery – visualization through computational fluid dynamics simulations, *Laryngoscope* Mar;126(3):E90-6. doi: 10.1002/lary.25666. PMID: PMC5084453
- 51) **Zhao K.**, Malhotra P., Rosen D., Dalton P. and Pribitkin EA. (2014) Computational Fluid Dynamics (CFD) as surgical planning tool: a pilot study on middle turbinate partial resection, *Anatomical Record*. Nov;297(11):2187-95. doi: 10.1002/ar.23033.
- 52) **Zhao K.**, Jiang J. (2014) What is Normal Nasal Airflow? – A Computational Study of 22 Healthy Adults, *International Forum of Allergy Rhinol*. Jun;4(6):435-46. doi: 10.1002/alr.21319
- 53) **Zhao K.**, Dalton P., Cowart BJ., Pribitkin EA.(2014) Re: In Reference to Regional Peak Mucosal Cooling Predicts the Perception of Nasal Patency. *Laryngoscope*. May;124(5):E211-2
- 54) **Zhao K.**, Jiang J., Pribitkin EA., Dalton P., Rosen D. Lyman B., Yee KK., Rawson NE., Cowart, BJ. (2014) Conductive olfactory losses in chronic rhinosinusitis? – A computational fluid dynamics study of 29 patients, *International Forum of Allergy Rhinol*. Apr; 4(4):298-308.
- 55) **Zhao K.**, Jiang J., Blacker K., Lyman B., Dalton P., Cowart BJ., Pribitkin EA. (2014) Regional Peak Mucosal Cooling Predicts the Perception of Nasal Patency, *Laryngoscope*, 124(3):589-95 (Cited: 11)
- 56) **Zhao K.**, Blaker K., Luo Y. Bryant B., Jiang J. (2011) Perceiving nasal patency through mucosal cooling rather than air temperature or nasal resistance, *Plos One* 6: pp. e24618(Cited: 10)
- 57) Dalton PH., Opiekun RE., Gould M., McDermott R., Wilson T., Maute C., Ozdener MH., **Zhao K.**, Emmett E., Lees PSJ., Herbert R., Moline J. (2010) Chemosensory Loss: Functional Consequences of the World Trade Center Disaster. *Environ Health Perspect* 118(9): 1251-1256. (Citations: 8)
- 58) Wise P.M., **Zhao K.**, and Wysocki C.J. (2010) Dynamics of nasal irritation from pulsed homologous alcohols. *Chem Senses*. 35(9): 823-9 PMID: PMC2980991
- 59) Jiang J.B., and **Zhao K.** (2010) Airflow and nanoparticle deposition in rat nose under various breathing and sniffing conditions —A computational evaluation of the unsteady and turbulent effect. *Journal of Aerosol Science*. 41: 1030–1043 PMID: PMC2976565 (Citations: 21)
- 60) Wise P.M., **Zhao K.**, and Wysocki C.J. (2009) Dynamics of nasal chemesthesis, *Ann N Y Acad Sci*. 1170:206-14 (Citations: 9)
- 61) Wise P.M., Toczydlowski, S.E., **Zhao K.**, and Wysocki C.J. (2009) Temporal integration in nasal lateralization of homologous propionates. *Inhalation Toxicology*, 21(10):819-27
- 62) Yang C.C., Scherer P.W., **Zhao K.** and Mozell M.M. (2007) Numerical modeling of odorant uptake in the rat nasal cavity, *Chem. Sense*. 32: 273–284. (Citations: 29)
- 63) **Zhao K.**, Dalton P., Yang G.C., and Scherer P.W. (2006) Numerical modeling of turbulent and laminar airflow and odorant transport during sniffing in the human and rat nose, *Chemical Senses*, 31: 107-118. (Citations: 66)
- 64) **Zhao K.**, Pribitkin E.D., Scherer P.W., Cowart B.J., Rosen D. and Dalton P. (2006) Numerical modeling of nasal obstruction and endoscopic surgical intervention: outcome to airflow and olfaction, *American Journal of Rhinology*, 20: 308–316,. (Citations: 32)
- 65) **Zhao K.**, Scherer P.W., Hajiloo A., and Dalton P. (2004). Effect of anatomy on human nasal air flow and odorant transport patterns: implications for olfaction, *Chemical Senses* 29: 365-379. (Citations: 121)

- 66) Kurtz D.B., **Zhao K.**, Hornung D.E., Scherer P.W. (2004). Experimental and numerical determination of odorant solubility in nasal and olfactory mucosa, *Chemical Senses*, 29, 763-773. (Citation: 40)
- 67) Ma Z.M., **Zhao K.** Qian W.J., and Zheng X.X. (1997) Ion Selective Microelectrode for Histamine and Application, *Chinese J. of Analytical chemistry*, 25(7), 750-754.

### **Invited Reviews and Book Chapters**

- 68) **Zhao K.** (2020) Editorial, *International Forum of Allergy Rhinol*, 34(6) 721-724, [doi: 10.1177/1945892420962738](https://doi.org/10.1177/1945892420962738)
- 69) Li C., **Zhao K.** (2020) Nasal Obstruction And Empty Nose Syndrome: What Are Our Noses Sensing? In: *Clinical & Biomedical Engineering of the Human Nose – A Computational Fluid Dynamics Approach*, Ed: Inthavong, K., Singh, N., Wong, E., Tu, J, Springer, Singapore.
- 70) **Zhao K.**, Frye R. (2015), “Nasal Patency and the Aerodynamics of Nasal Airflow - in Relation to Olfactory Function”, *the Handbook of Olfaction and Gustation*, 3<sup>rd</sup> ed, Ed: Richard L. Doty, Wiley-Blackwell, Hoboken, USA.
- 71) Scherer P.W., Huang J.W., and **Zhao K.** (2011). Capnography and the SPM Applied to Cardiac Output Recovery and Airway Structure and Function. In: *Capnogram: Clinical aspects, 2<sup>nd</sup> ed*”, Cambridge University Press, Cambridge, UK.
- 72) **Zhao K.**, and Dalton P. (2007) The way the wind blows - implications of modeling nasal airflow, *Current Allergy/Asthma Reports*, 7:117–125 (Citations: 15)
- 73) Scherer P.W. and **Zhao K.** (2004). Anatomic and physiological basis of volume capnography studied by the single path model. In: *Clinical aspects of volumetric capnogram*”, Ed: Gravenstein J. S., Jaffe M.B., and Paulus D.A., Cambridge University Press, 321-336, Cambridge, UK.

### **Invited Talk (seminar, grand round, panel, visiting professorship, keynote speaker)**

- Apr. 13<sup>th</sup>, 2022 “The way the wind blows: how nasal airflow potentially modulate our chemosensory perception”, invited seminar, Firmenich Inc., Global R&D.
- Oct. 28<sup>th</sup>, 2021 “A tale of two routes: retro- vs ortho-nasal olfaction”, AChemS Career Networking Seminar Series
- Jan. 28<sup>th</sup>, 2022 KEYNOTE TALK: “Nasal obstruction: what are our noses sensing?” Society for Computational Fluid Dynamics of the Nose & Airway (Virtual) <https://www.scona.org/>
- Apr. 22<sup>nd</sup>, 2021 “Novel treatment approaches for conductive olfactory losses & nasal obstruction symptoms”, Grand Rounds, Department of Otolaryngology, the Ohio State University
- Mar. 19<sup>th</sup>, 2015 “The way the wind blows: investigating the impediments in nasal airway”, Grand Rounds, Department of Otolaryngology, Vanderbilt University.
- Mar. 17<sup>th</sup>, 2015 “From nostril to receptors: nasal aerodynamics and its implications in mammalian nasal functions and diseases”, Grand Rounds, Department of Otolaryngology, Northwestern University.
- Feb. 25<sup>th</sup>, 2015 “Anosmia: A Sense of Hope”, Panelist, Lecture for continuing medical education (CME) for physicians, Jefferson University.
- Jan. 29<sup>th</sup>, 2015 “The way the wind blows: investigating the impediments of nasal airflow”, Grand Rounds, Department of Otolaryngology, University of Miami.
- Nov. 17<sup>th</sup>, 2009 “The history and future of computational nasal airflow modeling – the clinical and functional relevance?”, Beijing International Meeting on Research in Taste and Smell.

### **Multi-media**

Scope it out (a podcast for the International Forum of Allergy and Rhinology): Episode 53: Inferior meatus augmentation procedure (IMAP) normalizes nasal airflow patterns in empty nose syndrome patients via computational fluid dynamics (CFD) modeling with **Dr. Kai Zhao** and Dr. Jayakar Nayak

OSU study shows drastic loss of taste and smell among Delta variant COVID patients

<https://news.wosu.org/coronavirus/2022-06-07/osu-study-shows-drastic-loss-of-taste-and-smell-among-delta-variant-covid-patients>

Cat Noses Contain Twisted Labyrinths That Help Them Separate Smells

<https://www.scientificamerican.com/article/cat-noses-contain-twisted-labyrinths-that-help-them-separate-smells/>

## Oral presentations

1. K. Man, B. Spector, V. Formanek, K. Zhao, S.P. Travers, and C.T. Simons (2023), Chemosensory deficits in “long-hauler” subjects following COVID-19. AchemS annual meeting.
2. **Thomas Lepley, BS**, Zhenxing Wu, PhD, Zachary Root, BS, Barak Spector, BS, Robbie Chapman, Aspen Schneller, Bradley A Otto, MD, Kathleen M Kelly, MD, and Kai Zhao, PhD (2023) Can oxymetazoline simulate the outcomes of septoplasty and inferior turbinate reduction surgery? Combined Otolaryngology Spring Meetings (COSM)
3. Lepley J.T., Wu Z., Otto B.A., Kelly K., **Zhao K.** (2022) Computational fluid dynamic analysis of improved olfaction after dupilumab, ARS 68<sup>th</sup> annual meeting.
4. Brenda Shen, Zhenxing Wu, Barak Spector, Bradley Hittle, Gregory Wiet, **Kai Zhao** (2022) Optimizing surgical outcomes to prevent Empty Nose Syndrome through endoscopic sinus surgery simulator, AAO-HNSF annual meeting, Philadelphia. September 11.
5. Kym Man, Zhenxing Wu, Aayah Mohamed-Osman, **Kai Zhao**, Susan P. Travers, Christopher T. Simons (2022) A Confectionary-Based Screening Tool For Assessing Chemosensory Loss In Covid-19 Patients, AchemS annual meeting.
6. Zhipeng Lou, Menglong Lei, Haibo Dong, **Kai Zhao**, Chengyu Li (2021) Effects of wing-induced flow on the odor plume structures in an upwind surging flight of monarch butterfly, 74th Annual Meeting of the APS Division of Fluid Dynamics.
7. Kim, K. Farag A.A., Otto B.A., **Zhao K.** (2021) 3D PRINTING AS A PLANNING TOOL TO OPTIMIZE POST-SURGICAL SINONASAL SINUS IRRIGATION, Combined Otolaryngology Spring Meetings (COSM), Virtual.
8. Frusciante RP., Farag A.A., Otto B.A., **Zhao K.** (2021) Otolaryngologist Assessment of Nasal Septum Deviation, *COSM, virtual*.
9. “Nasal airflow and trigeminal sensory dysfunction but not aggressive surgery lead to Empty Nose Syndrome”, International symposium in olfaction and taste, (ISOT 2020, virtual oral presentation)
10. Impact of diffusivity and viscosity on taste perception – application of a porous medium model for human tongue surface. ISOT 2020 (virtual oral presentation). Aug. 3<sup>rd</sup>, 2020
11. Nasal trigeminal cool sensitivity but not resistance dictates obstruction symptoms in nasal Septal Deviation patients. ISOT 2020 (virtual oral presentation). Aug. 3<sup>rd</sup>, 2020
12. “Peak sinus pressures during sneezing in healthy controls and post-skull base surgery patients”, Rhinoworld, 2019, Chicago Jun. 7<sup>th</sup>, 2019
13. “Use 3D printing to visualize and optimize personal nasal sinus irrigation strategy”, Rhinoworld, 2019, Chicago Jun. 6<sup>th</sup>, 2019
14. “Nasal obstruction and empty nose syndrome – what are our noses sensing?”, Society for Computational Fluid Dynamics of the Nose & Airway (SCONA) 2019 Jun. 5<sup>th</sup>, 2019
15. “Future novel targeted treatment options of nasal obstruction and olfactory losses”, SCONA 2019. Jun. 5<sup>th</sup>, 2019
16. Taste of time – a porous medium model for human tongue surface and its implication to temporal profile of gustatory perception. Association for Chemoreception Sciences, Annual meeting. Apr. 13<sup>th</sup>, 2019
17. “A Prototype Endoscopic Sinus Surgery Simulator to Optimize Surgical Outcomes”, FDA Frontiers in Med device, Washington DC Mar. 14<sup>th</sup>, 2019

18. "Asymptomatic vs. symptomatic septal perforations: a computational fluid dynamics examination", American Rhinologic Society Annual Meeting. Oct. 5<sup>th</sup>, 2018
19. "Effective Relieve of Empty Nose Syndrome symptoms through a novel nasal plug that cost a few cents", American Rhinologic Society Annual Meeting. Oct. 6<sup>th</sup>, 2018
20. "CFD analysis of aggressive turbinate reductions: Is it a culprit of ENS?", American Rhinologic Society Annual Meeting. Oct. 6<sup>th</sup>, 2018
21. "Is there a connection between endoscopic endonasal skull base surgery and empty nose syndrome? A pilot CFD study", COSM American Rhinologic Society. Apr. 18<sup>th</sup>, 2018
22. "The untold truth about nasal obstruction – from a bioengineer's perspective", Grand Rounds, Department of Otolaryngology, Kansas University. Oct. 23<sup>rd</sup>, 2017
23. "Examine the abnormal nasal aerodynamics in empty nose syndrome", American Rhinologic Society Annual Meeting. Sep. 8<sup>th</sup>, 2017
24. "CFD evidence of posterior septectomy as viable treatment option for septal perforation," Combined Otolaryngology Spring Meetings (COSM), San Diego, California. Apr. 26<sup>th</sup>, 2017
25. "Effect of induced airflow on odor plume transportation in a fruit fly in forward flight," AChemS Annual Meeting, Bonita Springs, Florida, Apr. 16<sup>th</sup>, 2017
26. "Computational fluid dynamics (CFD) and trigeminal sensory examinations of empty nose syndrome patients: pre and post turbinate surgery", American Rhinology Society (ARS) Annual Meeting. Sep. 22<sup>th</sup>, 2016
27. Chengyu Li, Alexander Farag, Samuel McGhee, Edmund Pribitkin, Bradley Otto, Kai Zhao, "Examine the abnormal nasal aerodynamics in empty nose syndrome", American Rhinologic Society Annual Meeting 2017
28. Guillermo Maza, Chengyu Li, Bradley A. Otto, Alexander A. Farag, Ricardo L. Carrau, Kai Zhao, "Is there a connection between endoscopic endonasal skull base surgery and empty nose syndrome? A pilot CFD study" COSM American Rhinologic Society 2018.
29. "Computational fluid dynamics (CFD) and trigeminal sensory examinations of empty nose syndrome patients: pre and post turbinate surgery", American Rhinology Society (ARS) Annual Meeting.
30. Chengyu Li, Haibo Dong, and Kai Zhao, "Effect of induced airflow on odor plume transportation in a fruit fly in forward flight," AChemS Annual Meeting, Bonita Springs, Florida, April 2017.
31. Bradley A. Otto, Chengyu Li, Alexander A. Farag, Jilian P. Krebs, Kai Zhao, "CFD evidence of posterior septectomy as viable treatment option for septal perforation," Combined Otolaryngology Spring Meetings (COSM), San Diego, California, April 2017.
32. Nakesha King, Victoria Pepper, Cameron Best, Ekene Onwuka, Chengyu Li, Eric Heuer, Jed Johnson, Kai Zhao, Jonathan Grischkan, Christopher Breuer, and Tendy Chiang, "A pilot study: Using computational fluid dynamics to model physiologic airflow through an ovine tissue engineered tracheal graft," Association for Clinical and Translational Science (ACTS), Washington, D.C., April 2017.
33. "Computational fluid dynamics modeling of sinus irrigations before and after surgery", COSM- American Rhinology Society (ARS) Spring Meeting. April. 25<sup>th</sup>, 2015
34. "What is Normal Nasal Airflow? – A Computational Study of 22 Healthy Adults", American Academy of Otolaryngic Allergy (AAOA) Annual Meeting. Sep. 27<sup>th</sup>, 2013
35. "Conductive olfactory losses in chronic rhinosinusitis? – A computational fluid dynamics study of 29 patients", American Rhinology Society (ARS) Annual Meeting. Sep. 28<sup>th</sup>, 2013
36. "The history and future of computational nasal airflow modeling – the clinical and functional relevance?", Beijing International Meeting on Research in Taste and Smell. Nov. 17<sup>th</sup>, 2009
37. "Sensation of nasal patency through mucosal heat loss rather than air temperature", Rhinology World 2009 - *the combined meeting of four major Apr. 16<sup>th</sup>, 2009 Societies: The International Rhinological society (IRS), The International Symposium on Infection and Allergy of the Nose (ISIAN), The American Rhinological Society (ARS) and The American Academy of Otolaryngic Allergy (AAOA).*
38. "Objective assessment of the impact of chronic rhinosinusitis (CRS) on olfactory function", Rhinology World 2009. Apr. 18<sup>th</sup>, 2009
39. "Computational modeling of nasal airflow and odorant transport in patients with chronic rhinosinusitis", Rhinology world 2009. Apr. 18<sup>th</sup>, 2009
40. "Modeling of nasal airflow and odorant transport in patients with chronic rhinosinusitis", Biomedical engineering society (BMES) annual conference. Oct. 15<sup>th</sup>, 2006

41. "Numerical nasal airflow simulation in patients pre- & post- middle turbinate resection", American Rhinology Society (ARS) COSM Meeting. May. 19<sup>th</sup>, 2006
42. "Computational modeling of nasal airflow and odorant transport in patients with chronic rhinosinusitis", AchemS Annual Conference. Apr. 29<sup>th</sup>, 2006
43. "Modeling of airflow and odorant delivery pattern in a pre- & post-operative nasal cavity: a quantitative evaluation of surgical intervention", American Academy of Otolaryngology-- Head and Neck Surgery (AAO-HNS), Pennsylvania annual meeting, Philadelphia, PA. Jun. 11<sup>th</sup>, 2004
44. "Nasal airflow and odorant transport patterns: implications for odor perception", AchemS Annual Conference. Apr. 12<sup>th</sup>, 2003

### **Poster presentation (selected)**

1. Zhenxing Wu, Jianbo Jiang, Fritz W. Lischka, Scott J. McGrane, Yael Porat-Mesenco, Kai Zhao, Domestic Cat Nose Functions as a Highly Efficient Coiled Parallel Gas Chromatograph, AchemS Annual Conference, 2023
2. Thomas J. Lepley, BS; Zachary T. Root, BS; Zhenxing Wu, PhD, Bradley A. Otto, MD; Kathleen M. Kelly, MD; and Kai Zhao, PhD. Computational fluid dynamic modeling of the effect of Dupilumab in the management of surgical-resistant CRSwNP with anosmia, AchemS Annual Conference, 2023
3. K. Man, Z. Wu, S.P. Travers, C.T. Simons and K. Zhao, A Confectionary-based Tool for Prospectively Screening of COVID-19 related Chemosensory Loss in at-risk population, AchemS Annual Conference, 2023
4. Zachary T. Root, BS; Thomas J. Lepley, BS; Zhenxing Wu, PhD; Aspen R. Schneller, Robbie J. Chapman, Kathleen M. Kelly, MD; Bradley A. Otto, MD; and Kai Zhao, PhD. The Effects of Oxymetazoline on Nasal Aerodynamics in Patients with Chronic Nasal Obstruction, COSM American Rhinologic Society 2023.
5. Zaahir Turfe, Kai Zhao, James Palmer, John Craig, "Computational fluid dynamic modeling of maxillary sinus irrigation after maxillary antrostomy versus endoscopic medial maxillectomy", COSM American Rhinologic Society 2018.
6. Chengyu Li, Guillermo Maza, Bradley C. Hittle, Hector J. Medina-Fetterman, Bradley A. Otto, Alexander A. Farag, Gregory J. Wiet, Don Stredney, Kai Zhao "Endoscopic sinus surgery simulator to optimize surgical outcomes: a pilot study on conductive olfactory losses", COSM American Rhinologic Society 2018.
7. Per G. Djupesland, Kai Zhao, John C. Messina, Ramy A. Mahmoud, James N. Palmer, "Exhalation delivery system (eds) provides superior deposition of liquid in post-surgical cavities in comparison to conventional spray or irrigation modalities", COSM American Rhinologic Society 2018.
8. Ronald S. Nowak, Kai Zhao, Bradley Otto, Devin Mistry, Alexander A. Farag, "Silent sinus syndrome: 5% criteria", COSM American Rhinologic Society 2018.
9. Bradley Hittle, Chengyu Li, Guillermo Maza Malave, Hector J. Medina-Fetterman, Bradley A. Otto, Alexander A. Farag, Gregory Wiet, Don Stredney, Kai Zhao, "Developing endoscopic sinus surgery simulator to optimize surgical outcome to olfactory losses", American Rhinologic Society Annual Meeting 2017
10. Guillermo Maza, Chengyu Li, Bradley Hittle, Hector J Medina-Fetterman, Bradley A Otto, Alexander A Farag, Gabriela Zappitelli, Gregory J Wiet, Don Stredney, Kai Zhao, "Endoscopic Sinus Surgery Simulator To Optimize Surgical Outcomes: A Pilot Study On Conductive Olfactory Losses" AChemS Annual Meeting 2018.
11. Kanghyun Kim, Chengyu Li, Kai Zhao, "A Nasal Aerodynamics Perspective Of Retronasal Olfaction: Rodents Vs. Human", AChemS Annual Meeting 2018.
12. Chengyu Li, Haibo Dong, Kai Zhao, "Dual Functions Of Insect Wings: Balancing Aerodynamics And Olfaction", AChemS Annual Meeting 2018.
13. Chengyu Li, Alexander A. Farag, Guillermo Maza<sup>1</sup>, Sam McGhee, Michael A. Ciccone, Bhakthi Deshpande, Edmund A. Pribitkin, Bradley A. Otto, Kai Zhao, "Abnormal Nasal Aerodynamics And Trigeminal Functions In Empty Nose Syndrome Patients", AChemS Annual Meeting 2018.
14. Zhao, Zhenxing Wu, Gabriela Zappitelli, Bhakthi Deshpande (2022) Designing A "Smell-Aid" Through Enhancing Intranasal Air And Odorant Delivery Patterns, *AchemS annual meeting*.

15. Zhenxing Wu, Jillian P. Krebs, Barak M. Spector, Bradley A. Otto, Kai Zhao, Alexander A. Farag, Regional Peak Mucosal Cooling Predicts Treatment Outcomes Of Nasal Valve Obstruction, *AchemS annual meeting*
16. Kym Man, Aayah Mohamed-Osman, Kai Zhao, Susan P. Traver, Christopher T. Simons, Chemosensory Losses In Active Probable Delta And Omicron Variants Breakthrough Covid-19 Cases, *AchemS annual meeting*
17. Zhenxing Wu, Jianbo Jiang, Scott F. Lischka, Yael Porat-Mesenco, Kai Zhao, Domestic Cat Nose Functions As A Highly Efficient Coiled Parallel Gas Chromatograph, *AchemS annual meeting*
18. Kanghyun Kim, Thomas J. Lepley, Bradley A. Otto, Kai Zhao (2022) Use Of 3D Printing To Optimize Nasal And Olfactory Drug Delivery, *AchemS annual meeting*
19. Chengyu Li, Guillermo Maza, Bradley C. Hittle, Hector J. Medina-Fetterman, Bradley A. Otto, Alexander A. Farag, Gregory J. Wiet, Don Stredney, **Kai Zhao** “*Endoscopic sinus surgery simulator to optimize surgical outcomes: a pilot study on conductive olfactory losses*”, COSM American Rhinologic Society 2018.
20. Per G. Djupesland, **Kai Zhao**, John C. Messina, Ramy A. Mahmoud, James N. Palmer, “*Exhalation delivery system (eds) provides superior deposition of liquid in post-surgical cavities in comparison to conventional spray or irrigation modalities*”, COSM American Rhinologic Society 2018.
21. Ronald S. Nowak, **Kai Zhao**, Bradley Otto, Devin Mistry, Alexander A. Farag, “*Silent sinus syndrome: 5% criteria*”, COSM American Rhinologic Society 2018.
22. Bradley Hittle, Chengyu Li, Guillermo Maza Malave, Hector J. Medina-Fetterman, Bradley A. Otto, Alexander A. Farag, Gregory Wiet, Don Stredney, **Kai Zhao**, “*Developing endoscopic sinus surgery simulator to optimize surgical outcome to olfactory losses*”, American Rhinologic Society Annual Meeting 2017
23. Guillermo Maza, Chengyu Li, Bradley Hittle, Hector J Medina-Fetterman, Bradley A Otto, Alexander A Farag, Gabriela Zappitelli, Gregory J Wiet, Don Stredney, **Kai Zhao**, “*Endoscopic Sinus Surgery Simulator To Optimize Surgical Outcomes: A Pilot Study On Conductive Olfactory Losses*” AChemS Annual Meeting 2018.
24. Kanghyun Kim, Chengyu Li, **Kai Zhao**, “*A Nasal Aerodynamics Perspective Of Retronasal Olfaction: Rodents Vs. Human*”, AChemS Annual Meeting 2018.
25. Sniffing and nasal aerodynamics: pre-processing of odorant information?, Form and Function of the Olfactory System, HHMI Janelia farm 2010
26. Jiang J.B., Luo Y.H., Dishowitz M., Wright A.C., and Zhao K., The first quantitative model of the nasal aerodynamics in mouse, AchemS 2010
27. Jiang J.B. and **Zhao K.**, Deposition of inhaled particles in the olfactory region in rat and human nasal cavities during breathing, AchemS 2009.
28. **Zhao K.**, and Jiang J.B. Spatial and temporal odorant transport patterns in rat nose: a computational study, ISOT 2008.
29. Jiang J.B., and **Zhao K.** Quantifying mechanical stimuli in rat and human nasal models during breathing, ISOT 2008.

#### Patents filed:

- 1) **Zhao K.**, 3D printed personalized nasal replica and attachments to visualize and optimize nasal sinus irrigation strategy (US 62/839,423, US patent filed 4/21/2020).
- 2) **Zhao K.**, Nasal plug (PCT/US 2018/021464, PCT/US patent filed on 3/08/2018, US patent pending US 16/491,958).
- 3) **Zhao K.**, Kim K., Modified Nasal Plug for Nasal Airflow Modulation (US 62/979,707, provisional US patent filed 02/21/2020)
- 4) **Zhao K.**, Devices and methods for enhancing intranasal air and odorant delivery patterns (US 63/171,375, filed April 6, 2021)

#### **E. TEACHING AND MENTORING**

Advised mentee in the Ohio State University:

Postdoctoral fellows: Dr. Jianbo Jiang (2008-2012), currently R&D in Voith-Siemens (hydro-turbines)  
Dr. Chengyu Li (2016- 2018), currently Assistant Professor, Villanova Univ.  
Dr. Jennifer Malik (2018-2021), currently R&D in Battelle  
Dr. Zhenxing Wu (2018- )

Ph.D. candidate: Kanghyun Kim (2016-2021)

Undergrad: James Leach, Adam Jacobowitz, Jillian Krebs, Ryan Hutcheson, Samuel McGheel, Michael Ciccone, Gabriela Zappitelli, Barak Spector, Jennifer Markley, Zach Root, Drew Mountain

Medical Students:

Melissa Ardizzone, 2020 Medical Student Research Scholarship, OSU.

Margaret Wingo, 2020 Medical Student Research Scholarship, OSU.

Brenda Shen, 2020 Medical Student Research Scholarship, OSU.

Contributing as guest lecturer to UPENN Bioengineering Department BE 350, "Biomedical applications of fluid mechanics" (spring 2008).

Served as advisor for independent study UPENN Bioengineering Department BE 499

2008 - Dhinakaran Chinappen, "*Algorithms to determine minimum cross-sectional area in the human nasal cavity based on CT imaging*"

Advised students in the Monell research apprentice program:

2007 - Tao Yang (Master students in Computer Science, Clarkson University), "*The repeatability of image segmentation methods*"

2008 - Jenifer Shusterman (Psychology undergrad, Tufts), "*The effect of air temperature and humidity on nasal patency*"

2009 - Lisa Pretoria (Bioengineering Undergrad, U of Pennsylvania), "*Modeling the effect of nasal dilator on nasal airflow*"

2010 - Elizabeth Cushing (Chemistry Undergrad, Swarthmore U), "*An Improved Partition Model for Odor Detection Thresholds*".

2011 - Dianna Feng (Senior in high school, placed 1<sup>st</sup> in the final poster presentation). "*3D image analysis and reconstruction for rat nasal cavity*".

2012 - Lesenia Santiago (Senior in high school), "*Is anterior turbinate reduction better than posterior?*"

2013 - Lesenia Santiago (Biomedical Engineering Undergrad, Carnegie Mellon), "*Odor Propagation in a Room*".

2014 – Ngoc Doan (Chemical Engineering, Drexel U), "CFD simulation of sinus irrigation".