

**Kai Zhao, Ph.D.**

Office Address:

Department of Otolaryngology  
Ohio State University  
915 Olentangy River Rd.,  
Columbus, OH 43212

614-293-3857 (office)  
614-366-1794 (lab)  
614-293-7292 (fax)  
Email: Zhao.1949@osu.edu

**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)

**Appointments**

2015-current	Associate Professor (with Tenure), Department of Otolaryngology - Head&Neck Surgery, 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

**B. RESEARCH SUPPORT**

**Current research support**

“A confectionary-based screening tool for assessing chemosensory loss in COVID-19 patients”  
**NIH-NIDCD 3R01DC016112-04S1, PI: Susan Travers** (12/21/2020 – 12/20/2021, total cost \$305,085)  
Role: Co-Investigator (20%)

“Noninvasive Nasal Aid to Improve Nasal Obstruction Symptoms”  
Agency: **Ohio State Dept. of Education, Accelerator Awards, PI: Kai Zhao** (01/01/2020-6/31/2021, 1 year direct cost \$150,000)

“Optimizing surgical outcomes to olfactory losses through endoscopic sinus surgery simulator” Agency:  
**NIH-NIDCD R21 DC017530, PI: Kai Zhao** (3/01/2019-3/1/2021, 2 year direct cost \$275,000)

“Sinonasal Visualization and Quantification of the Effect of Oxymetazoline Nasal Spray”  
Agency: **Bayer, Inc., PI: Kai Zhao** (1 year total cost \$120,000)

“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

**Pending research supports**

Short-term and long-term impact of COVID-19 on multiple sensory systems  
Agency: **NIH-NIDCD, R01, PI: Kai Zhao** (submitted, 5 year total cost \$ \$3,238,813)

“Optimizing topical drug delivery for personalized treatment of chronic rhinosinusitis”,  
Agency: **NIH-NHLBI, R01, PI: Kai Zhao** (submitted, 5 year total cost \$2,595,017)

“Novel treatment options for conductive olfactory losses & nasal obstruction symptoms”,  
Agency: **NIH-NIDCD, R01, PI: Kai Zhao** (submitted, 5 year total cost \$1,900,000)

**Completed research support**

“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.

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

## 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

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

Journal Reviewers: *PNAS*, *Scientific Reports*, *Journal of the Royal Society Interface*, *Laryngoscope*, *Plos Comp. Biol.*, *Plos One*, *Neuroscience*, *American Journal of Rhinology*, *International Forum of Rhinology and Allergy*, *Acta Oto-laryngologica*, *Journal of Rhinology*, *Laryngoscope Investigative Otolaryngology*, *Medical Engineering & Physics*, *Chemical Senses*, *Chemoperception*, *Inhalation Toxicology*, *Medical & Biological Engineering & Computing*, *Journal of Aerosol Science*, *Journal of Biomechanical Engineering*, *Journal of biomechanics*, *Journal of Experimental Biology*, *Anatomical Record*, *Computer Methods in Biomechanics and Biomedical Engineering*, *Surgery Research and Practice*, *Computers in Biology and Medicine*, *Current Medical Imaging Reviews*, *BMC medical research method*, *Orthodontics and Craniofacial Research*, *surgery research and practice*, *Science of the Total Environment*, *International Journal of Computer Assisted Radiology and Surgery*, *Engineering computations*, *Attention Perception Psychophysics*, *Jama Facial plastic surgery*, *Journal of Food Engineering*, *International Journal for Numerical Methods in Biomedical Engineering*.

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=V1qXhSkAAAAJ&view\\_op=list\\_works&sortby=pubdate](https://scholar.google.com/citations?hl=en&user=V1qXhSkAAAAJ&view_op=list_works&sortby=pubdate)

<https://www.ncbi.nlm.nih.gov/sites/myncbi/kai.zhao.1/bibliography/48582655/public/?sort=date&direction=ascending>

## Invited Reviews and Book Chapters

Zhao K. (2020) Editorial, *International Forum of Allergy Rhinol*, 34(6) 721-724, doi: [10.1177/1945892420962738](https://doi.org/10.1177/1945892420962738)

- 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.
- 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.
- 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.
- 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)
- 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.

### Peer-reviewed Publications

#### Selected highlights

- 1) 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
- 2) Li C., Dong H. and **Zhao K.** (2018) A balance between aerodynamic and olfactory performance during flight in Drosophila, *Nature Communications* 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*, 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*, 34(6):2025-36

#### Complete list

- 5) 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* (In press).
- 6) 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).
- 7) Mateusz Choiński, Natalia Gawron, Agnieszka Pluta, Marta Sobańska, Anna R. Egbert, Przemysław Bieńkowski, Halina Sienkiewicz-Jarosz, Anna Ścińska-Bieńkowska, Bogna Szymańska, Andrzej Horban, Ewa Firląg-Burkacka, Tomasz Wolak, Mateusz Rusiniak, Robert Bornstein, **Kai Zhao**, Emilia Łojek (2020) On the relationship between olfactory sensitivity and personality in HIV-seropositive and healthy men, *Current Psychology*, 39:1063–1071, doi.org/10.1007/s12144-018-9822-x
- 8) Malik J., Dholakia S., Spector BM., Yang A., Kim D., Borchard NA., Thamboo A., **Zhao K.**, Nayak JV. (2020) 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*, 2020 Nov 29. doi:10.1002/alr.22720, PMC1636956
- 9) Kim K., Otto B.A., Farag A.A., **Zhao K.** (2020) 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 (in press).

- 10) Wu Z., Krebs J.P., Spector B.M., Otto B.A., **Zhao K.**, Farag A.A (2020) Regional peak mucosal cooling predicts radiofrequency treatment outcomes of nasal valve obstruction, *Laryngoscope*, Nov 3. doi: 10.1002/lary.29223.
- 11) Turfe Z., **Zhao K.**, Palmer J. and Craig J. (2020) Computational fluid dynamic modeling of maxillary sinus irrigation after maxillary antrotomy and modified endoscopic medial maxillectomy, *Journal of Laryngology and Otology*, doi.org/10.1017/S0022215121000013 (in press).
- 12) 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
- 13) **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
- 14) 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)
- 15) 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)
- 16) 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
- 17) 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
- 18) Mason E.C., McGhee S., **Zhao K.**, Chiang T., Matrk 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
- 19) 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. PMCID: PMC6535904
- 20) 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. PMC6358472
- 21) 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 PMCID: PMC6119110
- 22) 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 PMCID: PMC5942217
- 23) Li C., Jiang J., Kim K., Otto B.A., Farag A.A., Cowart BJ., Pribitkin EA. Dalton P., **Zhao K.**,(2018) Nasal structural and aerodynamic features that may benefit normal olfactory sensitivity, *Chemical Senses* 43(4), 229-237, PMCID: PMC5913651
- 24) 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. PMCID: PMC5872907
- 25) 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. PMCID: PMC6015742
- 26) 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. PMCID: PMC5694356

- 27) 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
- 28) 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
- 29) 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
- 30) 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
- 31) 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)
- 32) **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
- 33) **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.
- 34) **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
- 35) **Zhao K.**, Dalton P., Cowart B.J., Pribitkin EA.(2014) Re: In Reference to Regional Peak Mucosal Cooling Predicts the Perception of Nasal Patency. *Laryngoscope*. May;124(5):E211-2
- 36) **Zhao K.**, Jiang J., Pribitkin EA., Dalton P., Rosen D. Lyman B., Yee KK., Rawson NE., Cowart, B.J. (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.
- 37) **Zhao K.**, Jiang J., Blacker K., Lyman B., Dalton P., Cowart B.J., Pribitkin EA. (2014) Regional Peak Mucosal Cooling Predicts the Perception of Nasal Patency, *Laryngoscope*, 124(3):589-95 (Cited: 11)
- 38) **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)
- 39) 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)
- 40) 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
- 41) 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)
- 42) Wise P.M., **Zhao K.**, and Wysocki C.J. (2009) Dynamics of nasal chemesthesis, *Ann N Y Acad Sci*. 1170:206-14 (Citations: 9)
- 43) 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
- 44) 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)
- 45) **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)
- 46) **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)
- 47) **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)

- 48) 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)
- 49) 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.

### **Publications (submitted, in progress)**

- 50) Mason E.C., McGheel S., **Zhao K.**, Chiang T., Matrka L. (2019) CFD model in the infant airway before and after slide tracheoplasty for the management of complete tracheal rings, *laryngoscope* (submitted).

### **Oral presentations**

- Aug. 3<sup>rd</sup>, 2020 "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)
- Aug. 3<sup>rd</sup>, 2020 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 Nasal trigeminal cool sensitivity but not resistance dictates obstruction symptoms in nasal Septal Deviation patients. ISOT 2020 (virtual oral presentation).
- Jun. 7<sup>th</sup>, 2019 "Peak sinus pressures during sneezing in healthy controls and post-skull base surgery patients", Rhinoworld, 2019, Chicago
- Jun. 6<sup>th</sup>, 2019 "Use 3D printing to visualize and optimize personal nasal sinus irrigation strategy", Rhinoworld, 2019, Chicago
- Jun. 5<sup>th</sup>, 2019 "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 "Future novel targeted treatment options of nasal obstruction and olfactory losses", SCONA 2019.
- Apr. 13<sup>th</sup>, 2019 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.
- Mar. 14<sup>th</sup>, 2019 "A Prototype Endoscopic Sinus Surgery Simulator to Optimize Surgical Outcomes", FDA Frontiers in Med device, Washington DC
- Oct. 5<sup>th</sup>, 2018 "Asymptomatic vs. symptomatic septal perforations: a computational fluid dynamics examination", American Rhinologic Society Annual Meeting.
- Oct. 6<sup>th</sup>, 2018 "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 "CFD analysis of aggressive turbinate reductions: Is it a culprit of ENS?", American Rhinologic Society Annual Meeting.
- Apr. 18<sup>th</sup>, 2018 "Is there a connection between endoscopic endonasal skull base surgery and empty nose syndrome? A pilot CFD study", COSM American Rhinologic Society.
- Oct. 23<sup>rd</sup>, 2017 "The untold truth about nasal obstruction – from a bioengineer's perspective", Grand Rounds, Department of Otolaryngology, Kansas University.
- Sep. 8<sup>th</sup>, 2017 "Examine the abnormal nasal aerodynamics in empty nose syndrome", American Rhinologic Society Annual Meeting.
- Apr. 26<sup>th</sup>, 2017 "CFD evidence of posterior septectomy as viable treatment option for septal perforation," Combined Otolaryngology Spring Meetings (COSM), San Diego, California.
- Apr. 16<sup>th</sup>, 2017 "Effect of induced airflow on odor plume transportation in a fruit fly in forward flight," AChemS Annual Meeting, Bonita Springs, Florida,
- Sep. 22<sup>th</sup>, 2016 "Computational fluid dynamics (CFD) and trigeminal sensory examinations of empty nose syndrome patients: pre and post turbinate surgery", American Rhinology Society (ARS) Annual Meeting.
- April. 25<sup>th</sup>, 2015 "Computational fluid dynamics modeling of sinus irrigations before and after surgery", COSM-American Rhinology Society (ARS) Spring Meeting.

- 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.
- Sep. 27<sup>th</sup>, 2013 “What is Normal Nasal Airflow? – A Computational Study of 22 Healthy Adults”, American Academy of Otolaryngic Allergy (AAOA) Annual Meeting.
- Sep. 28<sup>th</sup>, 2013 “Conductive olfactory losses in chronic rhinosinusitis? – A computational fluid dynamics study of 29 patients”, American Rhinology Society (ARS) Annual Meeting.
- 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.
- Apr. 16<sup>th</sup>, 2009 “Sensation of nasal patency through mucosal heat loss rather than air temperature”, Rhinology World 2009 - *the combined meeting of four major 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).*
- Apr. 18<sup>th</sup>, 2009 “Objective assessment of the impact of chronic rhinosinusitis (CRS) on olfactory function”, Rhinology World 2009.
- Apr. 18<sup>th</sup>, 2009 “Computational modeling of nasal airflow and odorant transport in patients with chronic rhinosinusitis”, Rhinology world 2009.
- Oct. 15<sup>th</sup>, 2006 “Modeling of nasal airflow and odorant transport in patients with chronic rhinosinusitis”, Biomedical engineering society (BMES) annual conference.
- May. 19<sup>th</sup>, 2006 “Numerical nasal airflow simulation in patients pre- & post- middle turbinate resection”, American Rhinology Society (ARS) COSM Meeting.
- Apr. 29<sup>th</sup>, 2006 “Computational modeling of nasal airflow and odorant transport in patients with chronic rhinosinusitis”, AchemS Annual Conference.
- Jun. 11<sup>th</sup>, 2004 “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.
- Apr. 12<sup>th</sup>, 2003 “Nasal airflow and odorant transport patterns: implications for odor perception”, AchemS Annual Conference.

### Conferences Abstracts (selected)

1. 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.
2. 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.
3. Ronald S. Nowak, **Kai Zhao**, Bradley Otto, Devin Mistry, Alexander A. Farag, “*Silent sinus syndrome: 5% criteria*”, COSM American Rhinologic Society 2018.
4. 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
5. 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.



6. Kanghyun Kim, Chengyu Li, **Kai Zhao**, "A Nasal Aerodynamics Perspective Of Retronasal Olfaction: Rodents Vs. Human", AChemS Annual Meeting 2018.

Sniffing and nasal aerodynamics: pre-processing of odorant information?, Form and Function of the Olfactory System, HHMI Janelia farm 2010

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

Jiang J.B. and **Zhao K.**, Deposition of inhaled particles in the olfactory region in rat and human nasal cavities during breathing, AchemS 2009.

**Zhao K.**, and Jiang J.B. Spatial and temporal odorant transport patterns in rat nose: a computational study, ISOT 2008.

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)

**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 Student:

Melissa Ardizzone, 2020 Medical Student Research Scholarship, OSU.

Margaret Wingo, 2020 Medical Student Research Scholarship, OSU.

Brenda Shen, 2020 Medical Student Research Scholarship, OSU.

Noah Waldman, 2021 Medical Student Research Scholarship, OSU.

Lecture to residents Feb, 2016

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”*.