Thesis Project Portfolio

Differentiating Acute Otitis Media (AOM) from Otitis Media with Effusion (OME) using the Autofluorescence of Neutrophils

(Technical Paper)

Antibiotic Resistance and the Placebo Effect

(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Biomedical Engineering

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March 2, 2023

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Executive Summary

Antibiotic resistance is a global issue that has plagued the medical community for decades. Finger pointing runs rampant, and meanwhile millions globally die every year from pathogens which have mutated beyond treatment capabilities. Antibiotic overprescription is typically cited as a root cause, but the origin of overprescription itself remains incompletely understood. The two projects contained in this portfolio approach antibiotic overprescription by targeting two distinct driving forces behind overprescription: overprescription due to incorrect diagnosis, and overprescription despite correct diagnosis. The goal is not to establish which is the "true" root cause of antibiotic overprescription, but to approach an inarguably multifaceted issue with a similarly diversified set of solutions.

The focus of the technical project is to design a diagnostic tool to differentiate between different types of otitis media (OM), or middle ear inflammation. OM is one of the most common childhood illnesses (Schilder et al., 2016). OM can be classified into two types, Acute Otitis Media (AOM) and Otitis Media with Effusion (OME). Currently, there is a 50% misdiagnosis rate of OM type among pediatricians (Pichichero & Poole, 2001). This is of concern because the standards of care are different; acute otitis media (AOM) is bacterial and thus can be resolved with antibiotics, while otitis media with effusion (OME) is nonbacterial and may require surgical drainage of MEF (Schilder et al., 2016). NADPH is a promising biomarker for OM type, as it is found in exceptionally high levels in neutrophils and is autofluorescent. Neutrophils are a subtype of white blood cells that migrate to sites of infection, and are known to be found in higher numbers in AOM MEF in comparison to OME MEF (Elbistanli et al., 2017; Nassif et al., 1997). Therefore, the goal of the technical project is to develop a diagnostic method

capable of measuring NADPH autofluorescence levels with a degree of sensitivity that enables differentiation between the concentrations of NADPH found in healthy, AOM, and OME MEF.

The purpose of the STS research project is to elucidate the extent to which the patient prescriber dynamic serves as a factor in the overprescription of antibiotics. To this end, this research project aims to answer the following question: in the context of antibiotic resistance, how does the placebo effect impact antibiotic overprescription in the United States? Discourse analysis and evidence from documentary resources are utilized in order to answer this research question. Beginning with the discovery of penicillin, the history of antibiotic use is evaluated for their impacts on patient and prescriber attitudes towards antibiotics. The Social Construction of Technology (SCOT) then provides the framework for a discussion of how patients and prescribers, as distinct relevant social groups, have shaped the development of antibiotics and their meaning as a technological artifact. An analysis of action bias, power differentials, and economic and emotional factors provide insight into the enduring lack of closure of the meaning of the antibiotic. Results from this research project are pertinent to the fields of science technology and society, public health, psychology, and patient advocacy.

Working on the technical and STS projects concurrently was helpful in gaining an appreciation for how inexplicably linked social forces and technical knowledge are in the field of medicine. Writing a prescription, for example, is inherently a social activity, as the physician must speak with and examine the patient to determine a treatment plan. However, the techniques of assessment and the treatment plan itself frequently involve technologies, such as the otoscope and antibiotics in the case of otitis media. It became increasingly evident throughout the research process that medicine is a truly sociotechnical phenomenon, which reinforced that to stop antibiotic resistance, overprescription would need to be addressed on both technological and

interpersonal fronts. Not only are the capstone and STS projects related thematically, they are mutually dependent on the other's success.

Works Cited

Bauldry, S. A., Nasrallah, V. N., & Bass, D. A. (1992). Activation of NADPH oxidase in human neutrophils permeabilized with Staphylococcus aureus alpha-toxin. A lower Km when the enzyme is activated in situ. *The Journal of Biological Chemistry*, *267*(1), 323–330.

Elbistanli, M. S., Koçak, H. E., Acipayam, H., Yigider, A. P., Keskin, M., & Kayhan, F. T. (2017). The Predictive Value of Neutrophil-Lymphocyte and Platelet-Lymphocyte Ratio for the Effusion Viscosity in Otitis Media With Chronic Effusion. *Journal of Craniofacial Surgery*, *28*(3), e244. https://doi.org/10.1097/SCS.0000000000003452

Gartin, M., Brewis, A. A., & Schwartz, N. A. (2010). Nonprescription Antibiotic Therapy: *Medical Anthropology Quarterly*, *24*(1), 85–107. https://doi.org/10.1111/j.1548-1387.2010.01086.x

Nassif, P. S., Simpson, S. Q., Izzo, A. A., & Nicklaus, P. J. (1997). Interleukin-8 Concentration Predicts the Neutrophil Count in Middle Ear Effusion. *The Laryngoscope*, *107*(9), 1223–1227. https://doi.org/10.1097/00005537-199709000-00012

Pichichero, M. E., & Poole, M. D. (2001). Assessing Diagnostic Accuracy and Tympanocentesis Skills in the Management of Otitis Media. *Archives of Pediatrics & Adolescent Medicine*, *155*(10), 1137–1142. https://doi.org/10.1001/archpedi.155.10.1137

Rosenfeld, R. M., Shin, J. J., Schwartz, S. R., Coggins, R., Gagnon, L., Hackell, J. M., Hoelting, D., Hunter, L. L., Kummer, A. W., Payne, S. C., Poe, D. S., Veling, M., Vila, P. M., Walsh, S. A., & Corrigan, M. D. (2016). Clinical Practice Guideline: Otitis Media with Effusion (Update). *Otolaryngology–Head and Neck Surgery*, *154*(1_suppl), S1–S41. https://doi.org/10.1177/0194599815623467

Schilder, A. G. M., Chonmaitree, T., Cripps, A. W., Rosenfeld, R. M., Casselbrant, M. L.,

Haggard, M. P., & Venekamp, R. P. (2016). Otitis media. *Nature Reviews Disease Primers*, *2*(1), Article 1. https://doi.org/10.1038/nrdp.2016.63