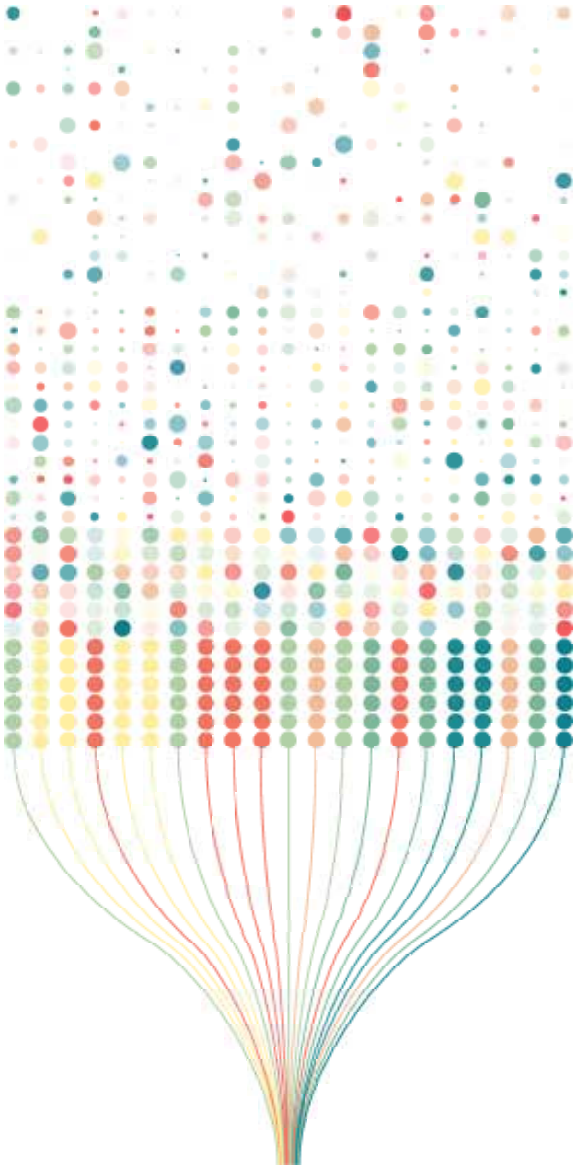
using data TO ADDRESS THE health challenges OF THE FUTURE



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contents

preface

In academic year 2021/2022, the Center for Faculty Scholarship at Fitchburg State University (FSU) convened a four-member panel to collaborate on research ideas related to the health field. The multidisciplinary panel, which comprises faculty from chemistry, mathematics, nursing, and psychology departments, met several times throughout the year to generate ideas and discuss their work. The panel brainstormed on the central theme, "Using Data to Address the Health Challenges of the Future," which culminated in presentations at the 3rd Annual Faculty Research Colloquium at FSU. The panel presented on using data to tackle health challenges related to malaria, HIV/AIDS, opioid addictions, and hearing loss.

Following their presentations, the panel now presents a report of their response to six questions related to their work. Due to the multidisciplinary nature of this work and the target audience, the panelists attempt to be less technical in this report. Each panelist is eager to discuss specifics of their work in detail should you contact them directly.

question

Question 1

What types of data that relate to health are used in your research?

DA: I am a chemist by training and my research is in the area of bioinorganic chemistry. The field of bioinorganic chemistry lies at the interface of biology and inorganic chemistry. I like to view bioinorganic chemistry as the aspect of chemistry that encompasses the fields of biology, biochemistry, inorganic chemistry, microbiology, pharmacology, and physiology.

In developing my research, I examine natural phenomena and relevant processes in the context of the various fields, study the types of processes they undergo, then use chemistry to understand why and how these processes occur. The goal is to work towards understanding disease transmission and prevention, as well as treating diseases.

In the last few years, my work was geared towards understanding the mechanism of action of quinoline-based compounds in treating malaria—arguably one of the oldest diseases known to mankind. In particular, my research focuses on studying the role of heme (the non-protein iron-containing portion of hemoglobin) in activating known antimalarial drugs for drug activity. The ultimate goal is to help design new antimalarial drugs that are more effective and to overcome the problem of antimalarial-drug resistance.

In regard to data I need for this work, I follow trends in malaria cases, drug and vaccine development, drug resistance reports, structure-function studies, etc. through peer-review articles and other reports to understand what has been done in the field. The data needed are both qualitative and quantitative as in those presented by the World Health Organization, WHO (World Health Organization, 2021), and the Center for Disease Control, CDC on experimental drug vaccine tests, and on available drugs for malaria treatment, parasite drug resistance, etc. Recently, I have relied heavily on experimental research data from consortia such as Malaria Drug Accelerator, MalDA (Yang, Ottilie et al. 2021), which is a group of 15 academic and industrial labs that share data, expertise and resources to accelerate malaria drug development. The data

reported by these agencies are easily accessible and often provide a good starting point to develop my research.

For example, there is conflicting information in the literature regarding the mechanism of action of antimalarial drugs in inhibiting hemozoin formation (the dimeric form of heme, which is non-toxic to the Plasmodium parasite). My current research focuses on studying this further. Specifically, I prepare synthetic heme models (chemically prepared similar compounds) in quantitative amounts and analyze them qualitatively through spectroscopy, X-ray crystallography, mass spectrometry and electrochemistry. Next, I treat the model compounds with the antimalarial drugs, then characterize the resulting products. The data obtained provides more information about the direct mode of binding of the antimalarial drugs, which subsequently could help in designing improved antimalarials.

TM: Currently many providers require patients in opioid use disorder treatment to attend individual counseling, despite lack of clear evidence it is necessary (Mariolis et al. 2019; Fiellin er al. 2013, Bickel et al. 2008). In order to examine the impact of counseling and other variables on opioid use disorder treatment outcomes, our group of researchers developed a software code to extract qualitative and quantitative data from electronic health records (EHR) from a national office-based outpatient addiction treatment center.

For example, one of the covariates impacting opioid use that we examined was trauma history. Information regarding trauma symptoms was generally entered in the EHR in free text format in several locations. We examined text from 500 patients in order to identify specific phrases used to identify trauma in the EHR. The following phrases were identified in free text fields and flagged as positive for trauma: ptsd and post-traumatic stress. In addition, a patient with a post-traumatic stress disorder (PTSD) diagnosis code was identified as positive for PTSD. After translating all text data to lowercase, syntax was written in order to identify patients who experienced trauma.

Our aim was to examine whether receiving individual counseling (nominal/categorical data) affected measures of treatment outcome such as taking prescribed Suboxone,

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opioid and drug use, years of total time spent in care, among others, (ratio data) in patients receiving opioid use disorder treatment (OUD). During the period when patients were receiving treatment, healthcare professionals collected health information which was added to the EHR. Since the health information was not originally collected for research purposes, this research method is referred to secondary data analysis.

MH: The field of psychology broadly investigates mental and physical health, not just psychological disorders. My own health-related research examines music as a tool to increase social connection, improve walking in Parkinson's disease patients, enhance creativity during altered states of consciousness, and decrease the risk of hearing loss. In these different research areas, the data take on very different forms. For example, I use: simple subjective reports of liking and social connection ("On a 9 point scale, how much do you like that person?"); time-series data of footsteps (a timestamp for every footstep or motion-capture data of body positions while walking); preferred and perceived loudness of music (e.g., ratings of how loud something sounds); and measures of brain activity (e.g., electroencephalography (EEG) and functional Magnetic Resonance Imaging (fMRI)) while in a trance.

BL: My collaborators and I model infectious disease dynamics using systems of ordinary differential equations. We have developed models for Buruli ulcer disease, HIV/AIDS, Ebola, COVID 19, canine distemper, and pseudorabies. We use time series data in many of our models to estimate key parameters that govern disease spread. Time series data is a sequence of data values that are indexed by equally spaced points in time. The values in the time series are usually either numbers or percentages of individuals that exist at a given time in certain subpopulations. Examples of time series data include the daily number of new cases or monthly deaths caused by a disease. Different types of data inform different parts of our models. For example, the number of infected individuals informs the rate of disease spread while the number of individuals in the recovered class tells us something about how long it takes for individuals to recover from the disease.

question 2

Question 2

Can you describe how data is collected and/or used in your discipline

DA: As a heavily experimental discipline, much of the data from my research are collected in the laboratory. My research group performs chemical synthesis of the several compounds in the lab, isolates the compounds, and characterizes them by a variety of techniques. In my current work, we prepare the ruthenium(II) octaethylporphyrin carbonyl complex, (OEP)Ru(CO) as a synthetic model for the heme group in blood, (PPIX)Fe, then study how quinoline-based antimalarial drugs react with these synthetic heme complexes. My research group determines the chemical and physical properties of the synthetic heme model via spectroscopy (Infrared, NMR, UV-visible), X-ray crystallography, and mass spectrometry. Next, we react the model compounds with the antimalarial drugs and monitor changes in their spectroscopic properties in solution. We then isolate the products of the reaction, re-crystallize them into single crystal samples and subject them to X-ray crystallographic studies. X-ray crystallography provides details about the exact mode of binding of the antimalarials to the heme center. For example, we have determined the X-ray crystal structure of the (OEP)Ru(CO)(Qnl) adduct (Qnl = quinoline), which reveals coordination of the quinoline group to the ruthenium center. This data suggests that mode of binding of the quinoline-based antimalarials in biological systems is through the iron center of heme.

Additionally, since electron transfer processes occur in biological systems, we subject the heme-drug adducts to electrochemical studies in solutions in order to determine their stability.

The data collected by my group would then be analyzed further by us (or another group) for potential application in drug design. Sometimes, it may be necessary to change the chemical, physical and electronic properties of the antimalarial drug by chemically incorporating different groups on the important pharmacophores of the antimalarial drug to

form new compounds. The new compounds formed could then be tested for effectiveness on the Plasmodium parasite both in vivo and in vitro by other researchers.

TM: The software code our research team developed was utilized to extract specific phrases from assessment data in the EHR that indicated whether a patient had or had not attended individual counseling, as well as numerical data from biological tests such as urine screens that identified the use of prescribed medications and substances such as opioids, benzodiazepines or alcohol.

The nominal and ratio data were correlated with past (greater than one year since the start of OUD treatment) or concurrent attendance at individual counseling during OUD treatment. Through statistical analyses the team was then able to determine how both types of counseling correlated with outcomes of OUD treatment.

MH: My fields–music psychology, timing, and hearing–are very broad and use many approaches. Studies can range from an in-depth qualitative case study of a single person to a big-data online study with millions of participants. My field also uses computational modeling, wherein researchers build and test models of how agents or brains work. Psychology has experienced an explosion of new datasets that are archived and freely available, and many journals now require that the raw data used in an article is publicly available. My work is also broad, and I typically run experimental studies in the lab or online. I've used existing data sets, and this was especially effective during pandemic lab shutdowns.

BL: The time series data we use is typically collected at the individual level by health officials and is then aggregated across regions by government organizations. Certain types of health data can be made available in open-access online repositories while other types must be protected due to confidentiality laws. We often formulate compartmental models based on the biology of the disease and then estimate parameters for our models using the time series data. This is often referred to as fitting our models to the data. Once we have a fully formulated model, we are able to use the model to consider how changes to the system impact future dynamics. Questions we consider include...

- How do different vaccination rates and/or the timing of vaccination rollout impact the number of cases of COVID 19?
- Can Kenya reach HIV/AIDS transmission goals set by the World Health Organization by eliminating societal stigma towards people with the disease?
- Could educating people about ways to avoid a disease prevent future outbreaks?

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question 3

Question 3

What challenges do you encounter trying to obtain data for your research? What was your workaround (if any) to the challenges you encountered?

DA: The first biggest challenge I have encountered is logistics. Chemistry research is expensive and requires investment in chemicals, equipment and other resources to keep up with changing trends in the field. As a four-year teaching institution, research in science can be quite challenging to do, yet research is a very important high impact practice for our students. The University does a good job providing some funds each year to support the work we do. For example, funds from FSU's Special Projects Grants have supported my work. The Biology/Chemistry department is equipped with very nice research equipment that allow faculty and students to work on collaborative research projects. I feel blessed to be able to use equipment such as Infrared spectrometers, UV-vis spectrophotometer, GC-MS spectrometers, etc. for my work.

There are, however, some essential equipment for my research that are unavailable at the moment. Many of the experiments I do in my work involve working under an oxygen-free environment, which has been very difficult to do in our labs. A standard equipment that is often used to maintain oxygen-free environments for research is a glovebox. I have managed to find a temporary solution by using chemical substance alternatives that are relatively more stable in air in place of the actual substances. Although we are able to obtain some data to inform our work, I find changing too many variables of my research sometimes leads to data that are inconclusive. I hope to pursue funding avenues for the purchase of the much-needed glovebox.

In addition, my research requires periodic analyses through X-ray crystallography and other specialized lab instrumentation. Admittedly, the latter instruments are expensive and probably not plausible to have at FSU at the moment, so we rely on larger research institutions for data

analysis from their equipment. I have established collaborations with experts in these institutions, who run samples for free and/or charge nominal fees for their services.

The second challenge I have encountered in my research is related to personnel for the work. As an educator, I involve students in my research. FSU has so many talented students who would strive in research. However, many of our students are from low-income families, and as a result need to work to support themselves and their families. This has made it difficult for many of our students to engage in research. In recent years, the University has made efforts to address this challenge by providing grants to pay students for doing research through the Special Projects grants. This is commendable and certainly worth pursuing. Hopefully, the allocated funds under this category would continue to be made available to support many students.

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The third challenge I faced is time to do research. Research in chemistry requires long blocks of lab time in order for one to accomplish much work. With a 4/4 teaching load spread across 4 days and one Research and Development Day (R&D), research can be challenging to accomplish. Sometimes the "R&D days" are used for grading and/or preparing for the next class's lesson. I simply make use of the free time I can get any day of the week. I have been able to do some of my research on school holidays and during winter and summer breaks.

TM: EHRs contain immense amounts of data and have the potential to test many hypotheses and research questions. One of the main benefits of utilizing them for our study was the presence of extant health information, however, to the extent that the data was collected for another purpose there was no guarantee that they contained what we needed in order to answer our specific research questions. In fact, the a priori power analysis that determined sample size had to be redone because only a few EHRs had the data we required to answer our main research question. Many of the EHRs had no documentation as to whether or not patients had attended counseling during or before OUD treatment. Therefore, despite the vast number of EHRs that were originally available (approximately 15,000) only a portion of the total could be used (669) due to missing information.

MH: One data challenge I discussed in depth in my talk was the importance of an appropriate sample size to make useful inferences. Historically, when starting a study, many people would simply use the same sample size as a similar published study; use a rule-of-thumb like ~20 subjects for each between-subjects condition (Lakens, 2022); or collect as much data as possible before a deadline or the end of the semester. Such approaches often lead to small sample sizes, which yield unreliable estimates of an effect and are "underpowered" meaning that the sample is too small to reliably find a significant effect even if it exists (Fraley & Vazire, 2014).

Unreliable estimates of effects from underpowered studies have contributed to psychology and other fields' "replication crisis"—the problem that many published studies do not replicate. In one well-known project, researchers attempted to replicate 100 previously published studies using high-powered designs and original materials when available; they found that about 2/3 of the original findings did not replicate, and those that did replicate had considerably smaller effect sizes than the published study (Open Science Collaboration, 2015). This has led to a reckoning for the field and ultimately to strengthened scientific practices.

Several improvements are now in place to safeguard against publishing unreliable results. For example, journals and grant agencies now typically require a formal justification of sample size, to ensure they're not publishing or funding underpowered studies. To figure out an appropriate sample size, many use a free online tool called G*Power (Faul et al., 2009). Another important methodological improvement is "open data", wherein raw data from published studies are publicly available; open data helps dissuade "P-hacking" where researchers attempt many tests and massage data until their p-value is significant. Another practice to decrease p-hacking and improve reliability is "pre-registration"–before collecting any data, researchers pre-register and publish their study design, hypothesis, and planned tests.

I've started adopting such "Open Science" practices and carefully consider sample size when designing new studies. Getting a large enough sample size can be challenging

and has forced me to take other approaches. For example, in a study on hearing loss, we performed an online survey to get an adequate sample and got 76 respondents in a few weeks (Gureckis & Hove, 2019). In another study, we used a "small-is-beautiful" approach (Smith & Little, 2018), where we had a small sample from a quarantine bubble (n=5), but each subject performed thousands of trials over the course of several weeks (5 one-hour sessions) to increase power and reliability (Collins & Hove, 2021). Another effective way to collect a lot of data in a short period of time was to collect motion-capture data from 100 concert attendees at the same time (Cameron, Hove, Trainor et al., 2022).

BL: Obtaining quality data in a timely manner are typical problems with developing mathematical models used to make projections. For instance, if one would like to inform the general public during an outbreak, obtaining enough data quick enough for it to have an impact is often a problem. Even if we are able to obtain data, it is often sparse and full of noise related to the collection process. Additionally, some diseases are well-studied and data is therefore widely available (for example, HIV/AIDS), while other diseases are neglected and data is challenging to obtain (for example, Buruli ulcer disease). Since our models are typically very complex, we risk overfitting models without enough quality data, which could produce unreliable projections that result in inconsistent advice. Our goal is to always do the best we can with the data that is available. Sometimes this means scaling back on our goals or simplifying a model to avoid overfitting. For example, while Buruli ulcer disease has multiple transmission routes (avenues for new infections), data related to the disease is so limited that we were forced to aggregate all transmission routes into a single infected class. The resulting model is less biologically accurate, but is able to be parameterized using the available data. Other times an abundance of quality data allows us to expand our model and/or provide more accurate predictions. For instance, when modeling HIV/AIDS in Kenya, survey data collected by the Kenyan government related to national perception of HIV/AIDS allowed us to include in our model the impact of stigma on disease spread.

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question 4

Question 4

What approaches have you found successful for doing research at Fitchburg State with a 4/4 teaching load and other teaching and service commitments?

DA: As an educator, nothing excites me more than involving students in my research. I spend a lot of time training students on techniques, developing their research skills, etc. This commitment to train them through introductory research courses and independent studies keeps me going in my research. With other teaching and service commitments, research can be difficult to accomplish. Chemistry research requires a lot of time, so I supervise a few students at a time. I recruit students for my research by participating in the Biology/Chemistry Department's Annual Science Symposium. I make efforts to work with my research student's schedule so they do not have class on my R&D Day. I encourage my students to present their work at different places, and some of whom have presented our work at the Undergraduate Research Conferences, local research meetings, as well as national meetings (Gangemi, et al., 2019; Gangemi, et al., 2020).

I keep myself updated on current trends by reading, serving as a reviewer for journal articles, as well as attending/presenting at conferences both online and in person (Awasabisah, et al, 2020). I make adjustments to my research as needed, and continue to work collaboratively with researchers in our university and in other universities.

TM: Firstly, I enjoy collaborating with teams of researchers, particularly, when they are multidisciplinary. So, often working on research and scholarly projects does not feel like "work." Examining results of research with persons of other disciplines allows for the generation of multiple perspectives. For example, I had the opportunity to work with researchers from psychology, criminal justice, as well as a GIS analyst and a behavioral specialist to examine factors contributing to the high rate of overdose deaths in Massachusetts, particularly

in the north central area. After completing the data analysis, we came together to make recommendations on an approach to address the opioid crisis to the Worcester DA's office.

My background was informed by my experience as a healthcare professional and addiction specialist, however, the recommendations were much more robust because of the different perspectives of members of our team. I happen to enjoy writing and generating scholarly articles so it does not feel like additional work at times. It can be challenging to fit everything in and of course, time management is essential. I always make a point of working on projects that I am particularly interested in as well.

MH: We all know the challenges of doing research at FSU with its limited resources, our 4/4 teaching load and substantial service commitments. Several things have helped me remain research productive.

I involve students in research and give them lots of flexibility on what project they work on, what skills they hone, and what they spend their time on. Music research is a good gateway into research and students often come with their own ideas. The ability to pursue their own interests (within reason) helps keep them motivated and productive. Without grad students in our department, motivated students here can take a bigger role and learn more skills than they would in bigger and more hierarchical labs (where they might do only mundane tasks like data collection and data entry).

One future challenge is how to support our students' research practica and independent studies, as many students don't have the time or money to pursue them (as they often require more hours per week than a standard class). Therefore, access to this high-impact practice becomes a question of equity.

I often collaborate with colleagues from other schools who have more resources and grad students and postdocs. These external collaborations keep me motivated (guilt is a good motivator for me … don't want to let other people down). Additionally, many Principal Investigators with big labs are stretched thin, and welcome my input, collaboration, and informal advising of their students. I can collaborate and be a middle author on big, impactful (and expensive) projects.

I enjoy collaborating with teams of researchers, particularly, when they are multidisciplinary. So, often working on research and scholarly projects does not feel like "work." Examining results of research with persons of other disciplines allows for the generation of multiple perspectives.

Keeping up to date with the field without getting bogged down in the minutia. I don't have time to read everything I want to read, but I stay on top of big directions in my field via social media, newsletters, monthly journal scans, and occasional conferences (more online than in-person in the last few years). This big picture view is helpful for doing impactful research, rather than just doing the next small step.

Actually doing some scholarship on my research day. For me, I still need to work on my classes, prep lectures, grade, attend meetings, etc. on my research day, but I do carve out several research hours (e.g., the morning) that are sacrosanct (i.e., no internet or email … like in church). Relatedly, I'm finally figuring out how to prioritize important things over urgent things.

BL: Managing my time and having several different groups of great collaborators has helped me stay on track with my research. My general experience with mathematical modeling projects is that some projects progress nicely towards completion/publication, while equally as many stall out before reaching a conclusion. For this reason I typically have multiple projects ongoing at a given time with different groups of collaborators in each. While this is sometimes overwhelming if each project is progressing, it also allows me to continue progressing with my research by ensuring I always have something to work on. My department chairs have done a great job of providing me with at least one research day each semester, and I do my very best to focus only on research during that day. I also maximize my time by using evening hours and summers to continue furthering projects as well.

question 5

Question 5

How did the data you utilized/obtained inform your research?

DA: It has been long established that heme plays an important role in activating antimalarials for drug activity. I was curious about the mechanism of action of the drugs. My group performed chemical synthesis of synthetic heme models and studied their reactions with quinoline-based antimalarials to produce a heme-drug adduct, which were characterized by spectroscopy. Single crystals of the heme-drug adducts were obtained and characterized by X-ray crystallography. The X-ray crystal structure revealed that quinoline-based drugs interact with the metal center of heme, thus inhibiting hemozoin formation. Electrochemical experiments via cyclic voltammetry revealed oxidations were porphyrin-centered and that these redox potentials correlate with the electron donating properties of the quinoline drugs.

TM: The results of our study found that patients with higher rates of OUD treatment and Suboxone use were more likely to demonstrate reduced opioid use. Further, patients with more frequent treatment interruptions were more likely to test positive for opioids. There was very little evidence that counseling during treatment had a positive impact on treatment utilization. There was virtually no evidence that counseling during OUD treatment affected Suboxone intake or opioid use. Although counseling may have some benefit for some patients in OUD treatment, the findings of our study do not support mandating counseling during treatment which may result in additional hardship for patients.

MH: At this point in my career, I know when to give up on an idea (life is short, so work on interesting questions) and when to dig deeper. For example, in a series of studies we discovered that body movement was affected by low-frequency sounds. Those early findings led to several follow-up studies trying to figure out the mechanism (e.g., low frequencies are encoded in the ear and as vibrations in the body) and how to use

it in applications (e.g., to improve gait in patient populations or promote social togetherness). Additionally, ten years ago when I first started doing research on the brain science underlying trance, it was a fringe topic and hard to publish, in spite of cross-cultural ubiquity of using repetitive drums to induce trance. We uncovered evidence indicating that drums are commonly used to induce trance because the drum sounds are so predictable that they require only minimal processing in the brain. This research area is now becoming a hot topic, and I'm working on several new related projects during my sabbatical and beyond.

BL: In order to run a given model to learn something about a disease or make future projections, all inputs (known as parameters) must have numeric values. Sometimes parameters are known for a given model, while other times they must be estimated from data. For example, when modeling the Ebola virus disease, we were able to locate in the literature the average time it takes for an infected individual to recover from the disease, but the transmission rate for our specific model structure was unknown. We use time series data as part of constrained optimization problems related to our models to estimate missing parameters that govern disease spread, such as a transmission rate. Once a given model has been parameterized, we can solve our model to make projections and consider the impact of intervention strategies. Further analyses include determining parameters with the largest influence on model dynamics, analyzing the impact of various interventions, making future projections, and identifying avenues for further research.

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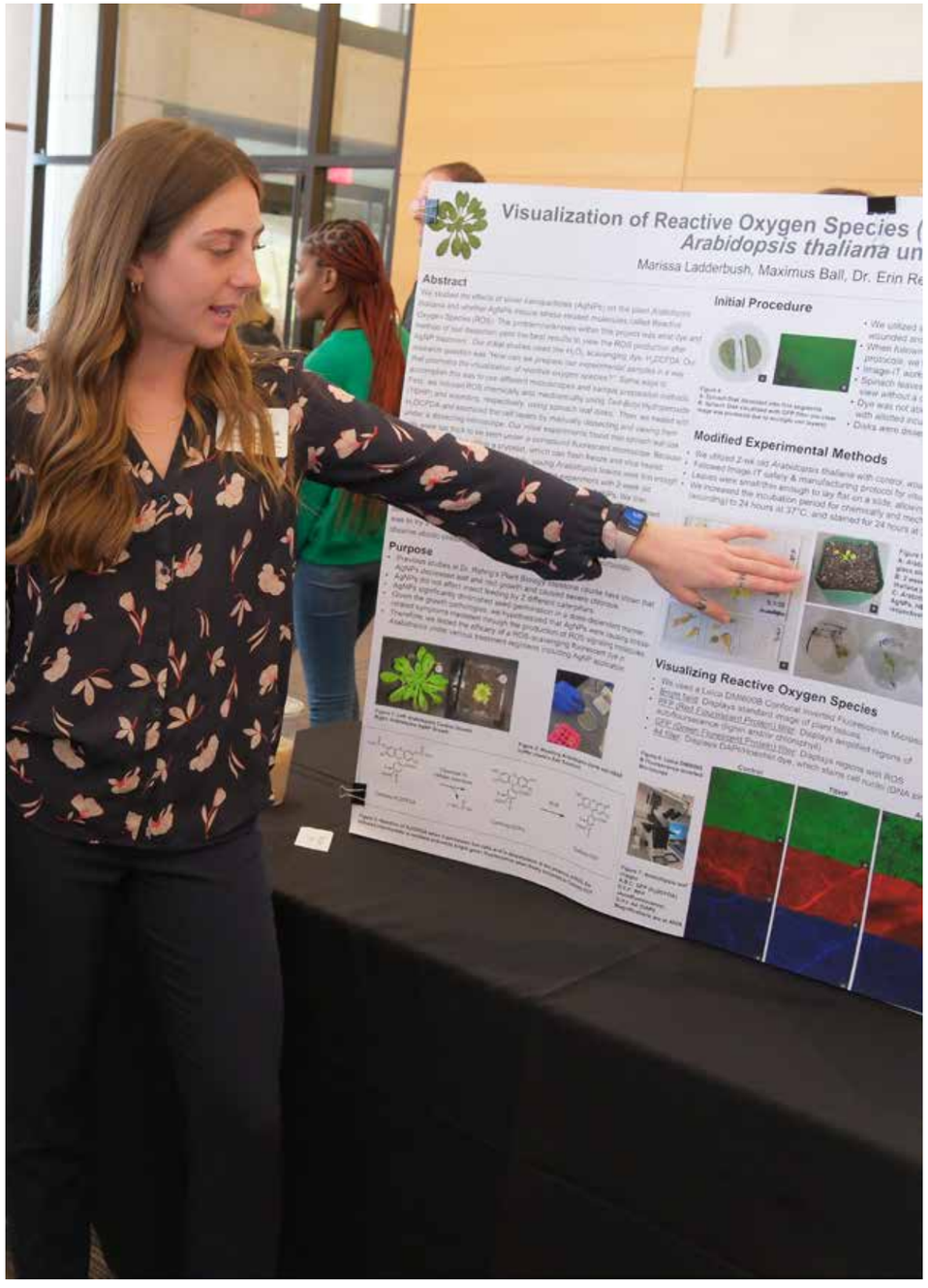

question 6

Question 6

How does your research address future health problems/challenges?

DA: The health challenges posed by malaria cannot be underestimated. Globally, there were an estimated 241 million cases of malaria in 2020 having increased from the 227 million estimated in 2019. Sadly, incident cases appear to be on the rise. Clearly, the COVID-19 pandemic had a negative impact on all the coordinated efforts from stakeholders in preventing transmissions, providing medications, etc. My research tackles this health challenge, especially in the area of understanding drug function, and could subsequently provide suggestions for improving drug effectiveness.

My research has shown that the quinoline-base antimalarials inhibit hemozoin formation. The antimalarials interact with the metal center of heme via the quinoline nitrogen. As a result, the quinoline group is an important pharmacophore in these antimalarials. This could be important in developing drugs that target the blood stage of the life cycle of the Plasmodium parasite. Natural products that contain the quinoline moiety should be tested for antimalarial activity. Quinine, Chloroquine and other quinoline-based drugs are quite cheaper and do not pose serious side effects. Perhaps, synthetic and medicinal chemists should consider incorporating one or more quinoline groups in developing target antimalarials especially in those that have dual action so they can help tackle the issue of drug resistance.

Finally, no one person/group can find all the solutions to any health challenge. A coordinated approach is required, similar to how the entire world tackled the devastating effects of the COVID-19 pandemic. Groups that work on diseases through different lenses and approaches should form consortiums and share their data similar to the MalDA group sponsored by the Bill and Melinda Gates Foundations and the Medicine for Malaria Venture (MMV), a public-private partnership founded in Switzerland. We need more collaborations. Health research data needs to be easily accessible. I am a strong proponent of OER in the health field.

TM: Given the severity of the current opioid crisis, it is essential to change current practice in which OUD treatment programs require patients to attend counseling in order to stay in treatment. This requirement is potentially harmful in that it is not evidence based and may result in premature discharge from treatment and additional hardship for patients. Further, lack of resources (monetary, transportation, childcare) and a high number of touchpoints during care preclude some patients from attending counseling. This in turn presents a potentially harmful barrier and thus reduces access to treatment for those who need it. Also, given the importance of treatment utilization, medication adherence, and treatment retention in preventing relapse of OUD, clinicians should actively work to improve retention in care and reduce the patient treatment burden (Mariolis et al., 2022).

Given the severity of the current opioid crisis, it is essential to change current practice in which OUD treatment programs require patients to attend counseling in order to stay in treatment. This requirement is potentially harmful in that it is not evidence based ...

MH: The main areas of my research apply to several critical health problems.

Much of my research looks at how music induces bodily movement (termed "groove"). Movement-inducing sound can be used to stabilize gait in Parkinson's patients. I'm working with colleagues to develop a wearable shoe-insert device that tracks footsteps and provides auditory feedback that can synchronize to footsteps and in turn help stabilize walk timing and decrease risk of falling.

Music-induced movement can also be harnessed to improve social cohesion (we've shown that people who move together like each other more). We're exploring if moving together could bring people together who have very different political viewpoints.

When studying groove, we've found that people move more with the low-frequencies and people enjoy cranking up their music to feel the vibrations from the loudspeakers in their body. We're exploring if directly stimulating the body with a vibrating backpack can provide that same pleasure without the ear-splitting loudness. Half of 12-35 year olds are at high risk of hearing loss, and hearing loss can lead to developmental delays, depression, and dementia.

Finally, one of the oldest healing traditions in the world is shamanism, and shamans use rhythmic drumming to induce an altered state of consciousness wherein they gain insight and creative solutions. My sabbatical project investigates sensorimotor-induced trance, as a means to increase insight and creativity that can be applied to any problem that requires an "out of the box" solution.

BL: The infectious disease models that we develop help address future health problems by estimating parameters relevant to a given disease that highlight the most important aspects of disease spread, which then produce projections that demonstrate how specific interventions, or lack thereof, result in different disease outcomes. This information combines to help inform officials so they can make the most impactful decisions possible. We have also developed new modeling approaches/techniques, formulated compartmental models for unexplored diseases, and furthered the literature related to parameter fitting. Each of these contributions to the disease modeling literature helps inform the development and parametrization of future infectious disease models.

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