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Abstract

Each day's work, whether a clinician, researcher or homemaker, focuses on investigative strategies and problem solving. Investigative methods and problem solving are rarely addressed formally in a medical school curriculum. Our goal with Investigative Methods and Tools was to convey to future clinician-scientists the skills to be able to confidently deal with information whether acquired from a patient, medical literature or in the laboratory. Our strategy is to convey to students major components of the investigative process including chasing curiosity, visualisation, modelling, experimental design and analysis. In addition, we depart from the traditional "jargon compliant" statistical vocabulary and focused on a more intuitive vocabulary. In this paper, we describe the rationale behind the development and implementation of a new course titled Investigative Methods and Tools. This new initiative is available for our students at the Duke-NUS Graduate Medical School Singapore. We outline the objectives and course contents for Investigative Methods and Tools, and highlight some of the unique approaches undertaken to bring forth a new, relevant and useful approach in conveying the central concepts underlying intuitive biostatistics and evidence-based medicine.

Keywords

integrated, investigative, methods, tools:, approach, critical, medicine, evidence-based, thinking, developing, biostatistics

Disciplines

Education | Social and Behavioral Sciences

Publication Details

Ha, T. C. & Starmer, F. (2008). Investigative Methods and Tools: Developing an Integrated Approach to Critical Thinking, Evidence-based Medicine and Biostatistics. SGH Proceedings, 17 (3), 160-163.

This journal article is available at Research Online: https://ro.uow.edu.au/sspapers/3899

Investigative Methods and Tools: Developing an Integrated Approach to Critical Thinking, Evidence-based Medicine and Biostatistics

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ABSTRACT

Each day's work, whether a clinician, researcher or homemaker, focuses on investigative strategies and problem solving. Investigative methods and problem solving are rarely addressed formally in a medical school curriculum. Our goal with Investigative Methods and Tools was to convey to future clinician-scientists the skills to be able to confidently deal with information whether acquired from a patient, medical literature or in the laboratory. Our strategy is to convey to students major components of the investigative process including chasing curiosity, visualisation, modelling, experimental design and analysis. In addition, we depart from the traditional "jargon compliant" statistical vocabulary and focused on a more intuitive vocabulary. In this paper, we describe the rationale behind the development and implementation of a new course titled Investigative Methods and Tools. This new initiative is available for our students at the Duke-NUS Graduate Medical School Singapore. We outline the objectives and course contents for Investigative Methods and Tools, and highlight some of the unique approaches undertaken to bring forth a new, relevant and useful approach in conveying the central concepts underlying intuitive biostatistics and evidence-based medicine.

Keywords: biostatistics, evidence-based medicine

BACKGROUND

Investigative Methods and Tools (IMT) is a course combining non-traditional intuitive biostatistics and evidence-based medicine. It is taught in the first year of the Duke-NUS Graduate Medical School Singapore. Unlike other courses in the first year that were adapted from the Duke University School of Medicine curriculum, there was no such course in the first year to use as a foundation for principles of biostatistics and evidence-based medicine.

An essential component of training DUKE-NUS clinician-scientists rests with their understanding of how to apply investigative tools and detect results that may reflect tool limitations, whether the data is derived from patients, laboratory studies or clinical trials. Clinician-scientists should be equally comfortable whether critically assessing the literature or planning, executing and interpreting data. The parallels between journal-driven analysis and laboratory/clinical study driven analysis led to the creation of this course. During their academic careers, students are exposed to many research articles and typically have no formal instruction during their university days on how to interpret such articles. Hence, this course was introduced early in the first year.

GOALS OF THE COURSE

In setting up this course, we felt that the most important skill for a clinician-scientist, succinctly put, is to be able to visualise and define exactly what it is they want to derive from their data, as well as to be able to interpret research articles confidently. The purpose was not to turn students into biostatisticians or epidemiologists, but in fact help them learn how to think critically. We wanted to impart some of the essential research skills to help the students know what to do when they do not know what to do.

This course was conceptualised to address 2 main goals: (1) enable students to visualise concepts, interpret the basic science/clinical literature incorporating the techniques of evidence-based medicine, and (2) enable them to approach data intuitively. A novel course goal was to enable students to learn how to interpret the medical literature and make up their minds as to whether to accept (believe) or not accept the reported results.

DEVELOPMENT OF THE COURSE

Biostatistics addresses ways to quantitatively explore patterns observed via models used to characterise biological processes. Specifically, we have repackaged biostatistics as traditionally presented in medical curricula. As the Molecules and Cells (one of the first year modules) course integrated materials from cell biology, microbiology and physiology, IMT addressed the investigative process from a research question to publishing results with quantified assessments of one's insights. We emphasise physical and chemical models that underlie biological processes as well as visualising models and data. Mastering the skills of visualisation, modelling, description, comparison and believability are essential whether applied to basic science research, patient care or clinical research. Most of the IMT tools are intuitive and most students would have already mastered them: visualising, recognising patterns, modelling (word and analytic), making visual comparisons and establishing a level of analytical and physiologic belief in the results of hypothesis tests.

A large emphasis is placed on the underlying chemistry and physics of biological processes. This is rarely, if ever, presented in the standard biostatistical textbooks. Therefore, it is reasonable to ask, why biostatistical procedures are derived from underlying models. Usually the models are linear models. How does one determine whether the underlying model is well suited to the target of investigation?

By assessing the physical and chemical processes involved in an investigation, we should have a good idea of the models used to describe these processes. Models provide a bridge between the biological processes under investigation and the statistical procedures used to place a quantitative value on the hypotheses. While there are statistical measures of the goodness of fit between a biostatistical model and data, they are of limited utility without a tool for linking the quality of the fit with expectations based on the underlying biological processes. In our course, we focused the student's awareness of the underlying physical or chemical model enabling the exploration of the quality of the statistical fit while minimising speculation.

During the design of the course, we looked at many textbooks and realised that we only use a small fraction of what is covered in traditional biostatistical texts. In addition, biostatistical texts tended to be devoid of illustrations designed to help visualise central concepts (law of large numbers, central limit theorem, link between sample size and standard deviation of the mean). Because the Internet offers a way to rapidly gain knowledge of an infrequently used concept, we decided to emphasise frequently used concepts at the expense of simply mentioning infrequently used tools. Taught in non-jargon terms, we felt that we could facilitate learning and reduce the boredom usually associated with biostatistics. We based our objectives on an *80/20 rule*. This objective at Duke-NUS Graduate Medical School is to convey the concepts we use 80% of the time while limiting the student exposure to infrequently used concepts. Why this rule? Tools, rules of thumb and so forth that we use 80% of the time are reused frequently enough to avoid the forgetting process. Tools, rules of thumb, concepts, insights that we infrequently use are often forgotten. We ask ourselves, why would we require the mastery of concepts that will be rarely used and mostly forgotten? Is this a potentially disabling strategy? Our working hypothesis is that frequently used tools such as Google, Wikipedia, Howstuffworks, PubMed and other resources can be productively incorporated into a just-in-time learning strategy as needed during episodes of patient care or within the laboratory. Good search skills enable just-in-time learning and provide more time for thinking and problem solving. We expose the students to the other 20% by including these infrequently used concepts in our lecture notes, application and providing web references so that students can learn about it and have access to it when required.

Based on Internet accessible resources as well as using the Internet for distribution of notes, we developed our own notes for the intuitive biostatistics component using a wiki as a medium for distributing our notes. The reason is that not only can we update our notes, but students have the option to also update and edit the notes.

OUTLINE OF THE COURSE

Based on our goals, we picked the main topics in biostatistics and evidence-based medicine for the 10 sessions of the course. The topics include:

a. Models, Visualisations and Descriptions. Every biostatistical procedure rests on a base of an implied model. How does this model relate to the physical/chemical/clinical processes under investigation?

b. Comparing Descriptions. Most research extends beyond description to comparing characterisations, visualising data and visually comparing results is a first step to understanding frequently used statistical tools. How does sample size alter visual presentation of comparisons?

c. Hypothesis testing: how to choose a hypothesis and what is so compelling about the null hypothesis compared with other possible hypotheses?

d. Believability: addresses how one feels about the results, combining statistical significance, physiological significance and clinical significance.

e. Frequently used biostatistical tools

f. Exploring longitudinal processes: follow up studies

g. Study designs in observational studies

h. Traps: bias, confounding, effect modification

i. Evaluating diagnostic tests

j. Randomised controlled trials

k. Systematic reviews and meta-analysis

HOW THE COURSE IS ORGANISED AND CONDUCTED

Central to the conduct of the course is the team based learning[1] (we have called it TeamGMS) format where students are given access to the reading materials about 3 weeks before the session. The team-based paradigm consists of 3 assessments, the individual readiness assessment (IRA), the group readiness assessment (GRA) and an application. The objectives for each session guide the students on what they need to learn for the session and also what they will be assessed in the readiness assessment tests. The IRA conducted at the beginning of each class is closed book and is used to measure individual mastery of the concepts outlined in the preparation material. The GRA is then conducted using the same questions as the IRA, and the group develops a single consensus answer. The GRA aims to resolve any issues the students may still have individually via the group, and assesses the student's readiness to apply the knowledge they have learnt. Following the GRA is an application, where a significant problem with perhaps 3 to 5 questions, is answered by the group. Thus, we build on both individual learning and group learning. Pre-class preparation is the time for individual learning and team learning is associated with group problem solving via the GRA and/or the application.

As stated above, we have written our own notes in order to steer away from the traditional way of teaching statistics. We wanted to avoid burdening students with statistical jargon and develop intuitive biostatistical concepts. Our intent is not to avoid statistical jargon, but to develop parallels between technical statistical terms/concepts so that students are able to identify them in the literature at large.

We designed our course to overlap learning associated concurrent first year courses. Therefore, when looking for literature references to key concepts, we limited our search to those papers used by other courses. This helps students to better interpret the articles from the other courses and provides an additional forum for discussion. This is a pass/fail course with a pass mark of 70%.

SUMMARY

Biostatistics is, without a doubt, one of the least interesting areas that medical students must master. Our experience has revealed that Biostatistics is often taught as an individual module. While frequently taught by example (exploring procedures used to address different types of clinical and laboratory investigations), there is rarely any repeating underlying theme that links the examples. We approached the problem of conveying biostatistical concepts to our students by first identifying the underlying themes of visualisation, modelling, describing, comparing and establishing a level of belief in the results. We have designed our module such that these terms are used instead of traditional statistical jargon (hypotheses, p-values, confidence intervals, sample size, power). Each of these traditional concepts are explored, but in our module, the context is visualisation, modelling and describing, i.e. intuitive concepts. We use papers from journals to introduce a concept and with our intuitive approach, provide a foundation for evidence-based medicine, experimental design and clinical trials.

We have delivered our course, Investigative Methods and Tools, through one class. The results were mixed, though there was uniform support for our emphasis on visualisation and rules of thumb (how to look at an illustration and approximate what the statistical result would likely be). With the second iteration, we are aligning our journal papers with those in the parallel basic science modules, thus providing a way to repeat and emphasise insights acquired within the basic science modules.

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