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BIostatISTICS AND EMERGING TROPICAL DISEASES

Do we need more biostatisticians?

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1 Biostatistics and its applications

An overview of *Statistical Methods for Biostatistics
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by Härdle, W., Mori, Y, and Vieu, P. (2007).

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Biostatistics is a field of science that develops and applies statistical methods to study life science-related problems that arise in fields such as biology, medicine, environment, agriculture, epidemiology and public health.

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In the beginning of the 20th century, biostatistics was associated with issues related to agriculture and genetics.

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After the Second World War, biostatistics interests shifted to medical-related applications where clinical trials were the primary focus of the work developed in this area.

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The advances in Biostatistics in the last 30 years have shown extremely relevant applications within the many broad fields where Biostatistics interacts.

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Emerging infectious diseases are diseases that have appeared in a population for the first time, or that have existed previously and are now rapidly increasing in incidence and/or geographic range.

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Emerging infectious diseases are diseases that have appeared in a population for the first time, or that have existed previously and are now rapidly increasing in incidence and/or geographic range.

Examples are Hantavirus, Avian Flu, West Nile Virus, Chikungunya Virus, Severe Acute Respiratory Syndrome (SARS) and Dengue.

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Examples are Hantavirus, Avian Flu, West Nile Virus, Chikungunya Virus, Severe Acute Respiratory Syndrome (SARS) and Dengue.

Climate changes and the continuing emergence of antibiotic resistance is a worldwide problem.

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Climate changes and the continuing emergence of antibiotic resistance is a worldwide problem.

Population increase, uncontrolled and unplanned urbanization, inadequate environmental conditions and international tourism.

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(Re-)Emergent and vector-borne diseases are dynamic systems adjusting continually in complex ways to changes in the environment.

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(Re-)Emergent and vector-borne diseases are dynamic systems adjusting continually in complex ways to changes in the environment.

Biostatistics has a tremendous challenge in trying to predict the spatio-temporal trends in such complex systems where the interaction of biological, environmental, economic and social factors will most certainly affect the emergence and spread of infectious diseases.



Longitudinal Data Analysis with Linear Regression

by Breitung, Slama and Werwatz

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In economics and epidemiology, studies in which subjects are followed over time (**logitudinal data**) or the observations are structured into groups sharing common unmeasured characteristics (**hierarchical data**) are quite frequent.



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In economics and epidemiology, studies in which subjects are followed over time (**logitudinal data**) or the observations are structured into groups sharing common unmeasured characteristics (**hierarchical data**) are quite frequent.

Classical regression models of the Generalized Linear Models (GLM) family will not apply in these studies since they assume statistical independence between the data, which is not the case when the data are grouped or when some subjects contribute for two or more observations.



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Classical regression models of the Generalized Linear Models (GLM) family will not apply in these studies since they assume statistical independence between the data, which is not the case when the data are grouped or when some subjects contribute for two or more observations.

Breitung *et al.* work is based on fixed and random-effect models in the case of linear regression. A particular attention is given in their study to unbalanced longitudinal data.



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The model is given by:

$$y_{it} = \alpha_i + x_{it}^T \beta + u_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T_i,$$

where x_{it} is the vector of explanatory variables for observation t of the individual (or group) i .

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where x_{it} is the vector of explanatory variables for observation t of the individual (or group) i .

The t index can correspond to time, if a subject is followed and observed at several occasions like in a cohort study, but it may also be a mere identifying variable, for instance in the case of a therapeutical trial about a new drug, realized in several hospitals (i will represent the hospitals and t the subject within the hospital).



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The difference between the fixed and random-effect model is how we consider the individual (or group) specific intercepts α_i . In the **fixed-effect model**, α_i are non-stochastic, which implies that the statistical inference is conditional on the individual (or group) effects α_i . In the **random-effect model**, α_i is a random variable with $E(\alpha_i) = 0$ and $E(\alpha_i^2) = \sigma_\alpha^2$.

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The fixed-effect model can be efficiently estimated by using least-squares estimation ("least-squares dummy-variables estimators").



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The difference between the fixed and random-effect model is how we consider the individual (or group) specific intercepts α_i . In the **fixed-effect model**, α_i are non-stochastic, which implies that the statistical inference is conditional on the individual (or group) effects α_i . In the **random-effect model**, α_i is a random variable with $E(\alpha_i) = 0$ and $E(\alpha_i^2) = \sigma_\alpha^2$.

The fixed-effect model can be efficiently estimated by using least-squares estimation ("least-squares dummy-variables estimators").

The random-effect model can be efficiently estimated by using the GLS estimator.



An Epidemiological Study about Reproductive Health

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Mothers with Chagas disease can transmit *Trypanosoma cruzi* to their fetuses, who often become carriers of the infection and are then at risk of developing severe cardiac disease later in the course of their lives. Early diagnosis allows appropriate treatment of newborns with a 100% efficacy.



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Mothers with Chagas disease can transmit *Trypanosoma cruzi* to their fetuses, who often become carriers of the infection and are then at risk of developing severe cardiac disease later in the course of their lives. Early diagnosis allows appropriate treatment of newborns with a 100% efficacy.

A cross-sectional sample of 1089 women infected with Chagas were questioned about the birth weight of all their children born between 1985 and 2000.



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The dependent variable is birth weight and the explanatory variables are: gestational length, age, parity of the mother (previous history of livebirth, no/yes) and infectious status of the offspring (positive/negative).

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The dependent variable is **birth weight** and the explanatory variables are: gestational length, age, parity of the mother (previous history of livebirth, no/yes) and infectious status of the offspring (positive/negative).

There was a total of 1963 births in the study period and the data can be considered as longitudinal data with a hierarchical structure, the women being the first level, and the pregnancy the second level.

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Parameters	Estimate	p-value	95% CI	
Constant	3413.3	0.000	3278.0	3548.0
Gestational Length	18.927	0.000	17.3	20.55
Mother's age	4.5912	0.082	-0.58	9.76
Paraty	88.389	0.000	51.36	125.4
Infectious status of the offspring	-152.53	0.000	-186.8	-118.3

Table: Estimated random-effects model for the birth-weight data set.

On average, an increase of one day in the duration of pregnancy was associated with a gain in weight of 18.9 grams, and infected newborns are 152.3 grams lighter than non-infected ones, with a 95% confidence interval of $[-186.8, -118.3]$ grams. We can also say that women who already had a child have a tendency to give birth to heavier babies (88.4 grams on average). At 5% significance level, age of the mother does not seem to have an effect on the child weight.



A Kernel Method Used for the Analysis of Replicated Micro-Array Experiments

by Gannoun, Liquefit, Saracco and Urfer

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Gene expression regulates the production of protein, which in turn governs many cellular processes in biological systems.



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The knowledge of gene expressions has **applications** ranging from basic research on the mechanism of the protein production diagnosing, staging, treating and preventing diseases.

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Gene expression regulates the production of protein, which in turn governs many cellular processes in biological systems.

The knowledge of gene expressions has **applications** ranging from basic research on the mechanism of the protein production diagnosing, staging, treating and preventing diseases.

Microarrays are part of the new class of biotechnologies which allow the monitoring of expression levels of thousands of genes simultaneously.



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A new **nonparametric** approach is proposed by Gannoun *et al.* to identify genes with altered expression under two experimental conditions, which may refer to samples drawn from two types of issues, tumors or cell lines, or at two points of time during important biological processes.

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The model can be written as:

$$Y_{ij} = \beta_i + \mu_i x_j + \epsilon_{ij},$$

where $x_j = 1$ for $1 \leq j \leq J_1$ and $x_j = 0$ for $J_1 + 1 \leq j \leq J_1 + J_2$, and ϵ_{ij} are independent random errors with mean 0. Hence $\beta_i + \mu_i$ and β_i are the mean expression levels of gene i under the two conditions respectively.



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Determining if a gene has differential expression is simply testing the hypotheses:

$$H_0 : \mu_i = 0 \text{ versus } H_1 : \mu_i \neq 0.$$



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Determining if a gene has differential expression is simply testing the hypotheses:

$$H_0 : \mu_i = 0 \text{ versus } H_1 : \mu_i \neq 0.$$

Some existing methods such as the t-Test and the Mixture Model approach rely on strong assumptions such as equal variances and normality which in practice can be violated.



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Some existing methods such as the t-Test and the Mixture Model approach rely on strong assumptions such as equal variances and normality which in practice can be violated.

A Kernel based method is proposed by Gannoun *et al.* to determine the rejection region of the above hypothesis test.

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Visceral leishmaniasis is a potentially fatal vector-borne infectious disease that leads to a variety of outcomes ranging from asymptomatic infection to symptomatic disease.

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Visceral leishmaniasis is a potentially fatal vector-borne infectious disease that leads to a variety of outcomes ranging from asymptomatic infection to symptomatic disease.

Hypothesis: Parasite would cause different changes in gene expression in both innate and adaptive cells of the immune system encountered early in infection.

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Visceral leishmaniasis is a potentially fatal vector-borne infectious disease that leads to a variety of outcomes ranging from asymptomatic infection to symptomatic disease.

Hypothesis: Parasite would cause different changes in gene expression in both innate and adaptive cells of the immune system encountered early in infection.

Goal: To find genes with differential expression between monocyte-derived macrophages alone (MDMs) and co-culture with autologous *Leishmania*-naïve T-cells.

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The new non-parametric approach was able to detect 33 differentially expressed genes that were not detected by the Mixture Model approach.

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Despite the many employment possibilities for biostatisticians in academia, government and industry, there is a shortage of them in Portugal.

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Despite the many employment possibilities for biostatisticians in academia, government and industry, there is a shortage of them in Portugal.

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Undergraduate Programs

- **The Universidade de Lisboa - Faculdade de Ciências and Universidade do Minho** are the only public universities to have an undergraduate program in Applied Statistics.

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Undergraduate Programs

- The **Universidade de Lisboa - Faculdade de Ciências** and **Universidade do Minho** are the only public universities to have an undergraduate program in Applied Statistics.
- Other programs in Mathematics across Portugal will teach 2 or 3 courses in Probability and Statistics with no particular emphasis in biostatistics.

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- Other programs in Mathematics across Portugal will teach 2 or 3 courses in Probability and Statistics with no particular emphasis in biostatistics.
- Programs such as Biomedical Sciences from the Universidade do Algarve, Bio-analytical Sciences from the Universidade de Coimbra - Faculdade de Farmácia and Public Health from the Universidade de Lisboa - Faculdade de Medicina will have a specific course in Biostatistics.

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Graduate Programs

- **Universidade da Beira Interior** with a Master's Program in Applied Statistics and a PhD Program in Applied Mathematics with several courses in Biostatistics.

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Graduate Programs

- **Universidade da Beira Interior** with a Master's Program in Applied Statistics and a PhD Program in Applied Mathematics with several courses in Biostatistics.
- **Universidade de Évora** with two Master's Programs in Applied Mathematics and Statistics with several courses in Biological Mathematics.

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- **Universidade da Beira Interior** with a Master's Program in Applied Statistics and a PhD Program in Applied Mathematics with several courses in Biostatistics.
- **Universidade de Évora** with two Master's Programs in Applied Mathematics and Statistics with several courses in Biological Mathematics.
- **Universidade Técnica de Lisboa - IST** with a Master's Program in Applied Mathematics with the possibility of several courses in Biostatistics.



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- **Universidade Nova de Lisboa - IHMT** with 5 different Master's Programs in Medical Sciences related areas all with specific courses in Biostatistics.

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Question?

Is this enough? Are we on the right path?

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Actions are needed to attract and engage students into biostatistics.

- Shortage of **well-trained biostatisticians** to collaborate with scientists in academia, industry, and government. The shortage is expected to worsen as senior biostatisticians retire.

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- Few undergraduate students **majoring in Science** are aware of the career opportunities afforded by biostatistics.
- **Summer Institutes for Training in Biostatistics (SIBS)** funded by NHLBI (National Heart Lung and Blood Institute) at Boston University, North Carolina State University, and the University of Wisconsin.

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- Six-week summer training course on biostatistics with relevant examples that include data collected in studies of heart, lung, blood, and sleep disorders.

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- The course targets **undergraduates** who are interested in learning about biostatistics.

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- Six-week summer training course on biostatistics with relevant examples that include data collected in studies of heart, lung, blood, and sleep disorders.
- The course targets **undergraduates** who are interested in learning about biostatistics.
- Providing an intensive introduction to biostatistical approaches and research by exposing participants to the principles, methodologies, uses, and applications of statistical methods in biomedical and clinical research.

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Our Reality

We need to start captivating students at a much earlier stage such as in high schools. **Teachers** and **Researchers** need to work together to accomplish the perfect symbiosis between theory and practice.

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Our Reality

We need to start captivating students at a much earlier stage such as in high schools. **Teachers** and **Researchers** need to work together to accomplish the perfect symbiosis between theory and practice.

Solution

Using real data sets, working with Real Problems will give students greater awareness of the importance of Statistics in their every day life.

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Solution

Using real data sets, working with Real Problems will give students greater awareness of the importance of Statistics in their every day life.

Biostatistics is a natural choice due to the richness and diversity of applications to which students can relate to.

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Collecting your own data using an iPod

The iPod Nano, together with Nike Sport Kit, offers a great tool for students to record their **distance**, **time**, and **calories** spent in any workout or during the day, given their weight.

By collecting the data in a class, or in multiple classes, and analyzing it you can engage students in trying to answer questions such as:

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- 1 What's the relationship between the calories you spent and the distance of your workout?

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By collecting the data in a class, or in multiple classes, and analyzing it you can engage students in trying to answer questions such as:

- 1 What's the relationship between the calories you spent and the distance of your workout?
- 2 Which class is the most fit?

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By collecting the data in a class, or in multiple classes, and analyzing it you can engage students in trying to answer questions such as:

- 1 What's the relationship between the calories you spent and the distance of your workout?
- 2 Which class is the most fit?
- 3 Which class did the most intensive workout?

Collecting your own data using an iPod

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By collecting the data in a class, or in multiple classes, and analyzing it you can engage students in trying to answer questions such as:

- 1 What's the relationship between the calories you spent and the distance of your workout?
- 2 Which class is the most fit?
- 3 Which class did the most intensive workout?
- 4 Who traveled the highest distance?

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Through a Network System

With the help of projects such as **ALEA** and **Census Vivo** these ideas can be implemented in different schools and take unthinkable proportions, like for example, the creation of a database of students' health habits.

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Through a Network System

With the help of projects such as **ALEA** and **Census Vivo** these ideas can be implemented in different schools and take unthinkable proportions, like for example, the creation of a database of students' health habits.

Thus...

Convincing teachers that (bio)statistics can actually engage and motivate students to study mathematics will **win teachers' attitudes** over toward statistics and minimize teachers' temptation to consistently leave statistics topics until the end of the school year to be taught, when very little can be said about the subject.

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In Biostatistics, research problems are generally motivated by real data sets and problems from Public Health, Biology and Medicine.

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In Biostatistics, research problems are generally motivated by real data sets and problems from Public Health, Biology and Medicine.

Biostatisticians play essential roles in **designing studies** and **analyzing data** from research problems. We help **formulate the scientific questions** to be answered, determine the **appropriate sampling techniques**, **coordinate data collection procedures**, **develop new statistical techniques** and carry out **statistical analyses** to answer those scientific questions.

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- ALEA - Acção Local de Estatística Aplicada. On-line site <http://www.alea.pt>.
- Apple Learning Interchange (ALI) network at <http://edcommunity.apple.com/ali>.
- de Sousa, B. (2006). Census Vivo: a different way of teaching statistics. On-line site <http://www.mct.uminho.pt/censusvivo>. Proceedings of the 56th Session of the International Statistical Institute. Lisbon, Portugal.
- Fahrmeir and Tutz, (1994). *Multivariate Statistical Modelling Based on Generalized Linear Models*, Springer Series in Statistics.
- Golub, T.R., Slonim, D.K., Tamayo, P., Huard, C., Gaasenbeek, M., Mesirov, J.P., Coller, H., Loh, M.L., Downing, J.R., Caligiuri, M.A., Bloomfield, C.D., and Lander, E.S. (1999). Molecular classification of cancer: class discovery and class prediction by gene expression monitoring. *Science*, **286**, 531-537.
- Härdle, W., Mori, Y, and Vieu, P. (2007). **Statistical Methods for Biostatistics and Related Fields**, Springer.
- Koenker, R. and Bassett, G. (1978). Regression Quantiles. *Econometrica*, **46**, 33-50.
- Li, K.C. (1991). Sliced Inverse Regression for Dimension Reduction (with discussion). *J. Amer. Stat. Assoc.*, **86**, 316-342.
- Ramsay, J.O. and Dalzell, C.J. (1993). Some Tools for Functional Data Analysis. *Journal of the Royal Statistics Society, series B*, **3**, 539-572.
- Summer Institutes for Training in Biostatistics (SIBS). On-line site <http://www.nhlbi.nih.gov/funding/training/redbook/sibsweb.htm>.

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Thank you very much.