KEY FUTURE CAREERS FOR HEALTH TECHNOLOGY INNOVATION

CROATIAN Clinical Brothers in Arms: Biomedical Engineers & Medical Physicists

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thank the organizers for the invitation and support!

- founded in 1984 as the Croatian Medical and Biological Engineering Society (CROMBES)
- since 1993 full member of the International Federation for Medical and Biological Engineering (IFMBE)
- and the European Federation of Organizations for Medical Physics (EFOMP)
- in 2013 change of name: Croatian Medical and Biological Engineering Society to Croatian Biomedical Engineering and Medical Physics Society
- about 150 ordinary, associate or honorary members with higher education and working in relation to BME & MP
INTRODUCTION

Location of Croatia (dark green): – in Europe (green & dark grey); – in the European Union (green)
<table>
<thead>
<tr>
<th>Capital and largest city</th>
<th>Zagreb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official languages</td>
<td>Croatian</td>
</tr>
<tr>
<td>Writing system</td>
<td>Latin</td>
</tr>
<tr>
<td>Ethnic groups (2011)</td>
<td>90.42% Croats, 4.36% Serbs, 5.22% others</td>
</tr>
<tr>
<td>Religion (2011)</td>
<td>91.08% Christians, 4.57% Irreligious, 1.47% Muslims, 2.90% others</td>
</tr>
<tr>
<td>Demonym</td>
<td>Croatian</td>
</tr>
<tr>
<td>Government</td>
<td>Unitary parliamentary constitutional republic</td>
</tr>
<tr>
<td>President</td>
<td>Kolinda Grabar-Kitarović</td>
</tr>
<tr>
<td>Prime Minister</td>
<td>Andrej Plenković</td>
</tr>
<tr>
<td>Speaker of Parliament</td>
<td>Gordan Jandrokić</td>
</tr>
<tr>
<td>Chief Justice</td>
<td>Miroslav Šeparović</td>
</tr>
<tr>
<td>Legislature</td>
<td>Sabor</td>
</tr>
<tr>
<td>Establishment</td>
<td>6th century, 7th century, 925, 1102, 1 January 1527, 29 October 1918, 4 December 1918, 25 June 1991, 1 July 2013</td>
</tr>
</tbody>
</table>

Location of Croatia (dark green): – in Europe (green & dark grey); – in the European Union (green)
INTRODUCTION

Croatian community of clinical biomedical engineers & medical physicists is small but is dreaming big!

[size doesn’t matter ]

Mala zemlja. Veliki snovi. Small country, big dreams.
• Nikola Tesla (Smiljan, Croatia, 1856 - New York, USA, 1943)
• 2018 is the 75th anniversary of his death
• ingenious engineer, physicist, scientist and inventor
biomedical engineering & medical physics inventions

- high-frequency high-voltage transformers
- X-rays and devices
- ozone generator
- muscle fatigue relieve oscillator...

Tesla high-frequency currents, Teslinization
(ex. medical diathermy, electrotherapy)

Tesla \([ \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-1} ]\) derived SI-unit of magnetic flux density
(ex. magnetic resonance imaging)
BACK TO THE FUTURE

- 117 registered US-patents

- curiosity!
  after Nikola Tesla, clinical engineer Božidar Ferek-Petrić (Zagreb, Croatia, 1955 - ) is a person from Croatia with the second highest number of registered US-patents (41 biomedical patents)!

1980-1998 clinical engineer in the University Hospital Centre Zagreb, Department of Cardiology, Zagreb, Croatia
Medical error—the third leading cause of death in the US

Medical error is not included on death certificates or in rankings of cause of death. Martin Makary and Michael Daniel assess its contribution to mortality and call for better reporting.

Martin A Makary professor, Michael Daniel research fellow
Department of Surgery, Johns Hopkins University School of Medicine, Baltimore, MD 21287, USA


Based on our estimate, medical error is the 3rd most common cause of death in the US.
1. Ransomware and Other Cybersecurity Threats to Healthcare Delivery Can Endanger Patients
2. Endoscope Reprocessing Failures Continue to Expose Patients to Infection Risk
3. Mattresses and Covers May Be Infected by Body Fluids and Microbiological Contaminants
4. Missed Alarms May Result from Inappropriately Configured Secondary Notification Devices and Systems
5. Improper Cleaning May Cause Device Malfunctions, Equipment Failures, and Potential for Patient Injury
6. Unholstered Electrosurgical Active Electrodes Can Lead to Patient Burns
7. Inadequate Use of Digital Imaging Tools May Lead to Unnecessary Radiation Exposure
8. Workarounds Can Negate the Safety Advantages of Bar-Coded Medication Administration Systems
9. Flaws in Medical Device Networking Can Lead to Delayed or Inappropriate Care
10. Slow Adoption of Safer Enteral Feeding Connectors Leaves Patients at Risk
Croatian classification of scientific and artistic areas

1. **natural sciences** (FIELDS: 1.01. Mathematics; 1.02. **Physics**; 1.03. Geology; 1.04. **Chemistry**; 1.05. Biology; 1.06. Geophysics; 1.07. Interdisciplinary Natural Sciences)


3. **biomedicine and health** (FIELDS: 3.01. Fundamental medical sciences, 3.02. Clinical medical sciences; 3.03. Public health and health care; 3.04. Veterinary medicine; 3.05. Dental medicine; 3.06. **Pharmacy**)

4. **biotechnical sciences** (FIELDS: 4.01. Agriculture; 4.02. Forestry; 4.03. Wood technology; 4.04. **Biotechnology**; 4.05. **Nutritional technology**; 4.06. Interdisciplinary biotechnical sciences)

5. social sciences

6. humanistic sciences

7. arts

8. interdisciplinary areas of science

9. interdisciplinary areas of art
1. scientific area of **natural sciences**

   *engineering/research-oriented*  
   *teaching/education-oriented*

   after the words „graduated engineer” or after the word „professor” is added a name that is derived from the field of science or from the profession in which the studies are organized and performed

**examples:**

**graduate physics engineer** (croat. diplomirani inženjer fizike)  
**professor of physics** (croat. profesor fizike)
1. scientific area of **natural sciences**

   *engineering/research-oriented*

   or

   *teaching/education-oriented*

under-graduate (3y) plus graduate (2y) university study or integrated under-graduate and graduate (3y+2y) university study leading to master's degree

*examples:*

**master of physics - mag. phys.**

(croat. magistat fizike)

**master of physics education - mag. educ. phys.**

(croat. magistat edukacije fizike)
2. scientific field of **technical sciences**

4. scientific field of **biotechnical sciences**

after the words „graduate engineer” is added a name that is derived from the field of science or from the profession in which the studies are organized and performed

*examples:*

**graduate electrical engineer**
(croat. diplomirani inženjer elektrotehnike)

**graduate computer engineer**
(croat. diplomirani inženjer računarstva)

**graduate mechanical engineer**
(croat. diplomirani inženjer strojarstva)

**graduate biotechnology engineer**
(croat. diplomirani inženjer biotehnologije)
2. scientific field of **technical sciences**

4. scientific field of **biotechnical sciences**

under-graduate (3y) plus graduate (2y) university study leading to master’s engineering degree

*examples:*

**master of electrical engineering - mag. ing. el.**
(croat. magistar inženjer elektrotehnike)

**master of computer engineering - mag. ing. comp.**
(croat. magistar inženjer elektrotehnike)

**master of mechanical engineering - mag. ing. mech.**
(croat. diplomirani inženjer strojarstva)

**master of biotechnology engineering - mag. ing. biotech.**
(croat. diplomirani inženjer biotehnologije)
3. scientific area of **biomedicine and health** field

3.06. pharmacy branches

3.06.01. pharmacy
3.06.02. medical biochemistry

after the words „graduate engineer” is added a name that is derived from the field of science or from the profession in which the studies are organized and performed

*examples:*

**graduate engineer of pharmacy / master of pharmacy**
(croat. diplomirani inženjer farmacije / magistar farmacije)

**graduate engineer of medical biochemistry**
(croat. diplomirani inženjer medicinske biokemije)
3. scientific area of **biomedicine and health** field

3.06. **pharmacy** branches

3.06.01. **pharmacy**

3.06.02. **medical biochemistry**

integrated under-graduate and graduate (3y+2y) university study leading to master's degree

*examples:*

**master of pharmacy** - mag. pharm.
(croat. magistar farmacije)

**master of medical biochemistry** - mag. med. biochem.
(croat. magistar medicinske biokemije)
Opinion of the European Economic and Social Committee on Promoting the European single market combining biomedical engineering with the medical and care services industry

(2015/C 291/07)

1. Conclusions and recommendations

1.1. Biomedical Engineering is not simply a subset of modern medicine. Modern medicine predominantly secures important advances through the use of the products of biomedical engineering.\(^{(1)}\).
until 2010 and according to the hospital act on its internal organizational structure and job profiles (systematization), the job title „electrical/electronic engineer” & „physicist” were systematized in 10 clinical departments (gynecology and obstetrics, cardiology, surgery, medical biochemistry, neurology, nuclear medicine, orthopedics, otorhinolaryngology, radiotherapy and oncology)

from 2014 and according to the new hospital act on its internal organizational structure and job profiles (systematization), the job title „medical engineer” & „medical physicist” were finally profiled, but in only 5 clinical departments (gynecology and obstetrics, neurology, nuclear medicine, radiotherapy and oncology, medical physics)

1990s: 8 clinical engineers (EE) and 4 medical physicists
2010s: 4 clinical engineers (EE) and 16 medical physicists

[20 biologists, 4 chemists]
Salary Coefficients of Job Complexity in Healthcare Public Service from 2014 onwards

Jobs/positions and coefficients of job complexity (i.e. coefficients of basic salary) for workers with 4+ year university degree who are employed in health care sector of public services in Croatia:

non-health worker, PhD (ex. biomedical engineer PhD) 1.571
who participates in the process of diagnosis and treatment
molecular biologist, biologist, cytogeneticist, 1.571
psychologist, phonetician, medical physicist (PhD, MSc, BSc) and
educational rehabilitator
who participates in the process of diagnosis and treatment
non-health worker, MSc (ex. biomedical engineer MSc) 1.513
who participates in the process of diagnosis and treatment
non-health worker, BSc (ex. biomedical engineer BSc) 1.445
who participates in the process of diagnosis and treatment
### Salary Coefficients of Job Complexity from 2014 onwards

<table>
<thead>
<tr>
<th>Position Description</th>
<th>Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>dr.med., specialist, subspecialist, PhD, in hospital/state health institute</td>
<td>2,361</td>
</tr>
<tr>
<td>dr.med., specialist, subspecialist, MSc, in hospital/state health institute</td>
<td>2,336</td>
</tr>
<tr>
<td>dr.med., specialist, subspecialist, primarius, in hospital/state health institute</td>
<td>2,317</td>
</tr>
<tr>
<td>dr.med., specialist, subspecialist, in hospital/state health institute</td>
<td>2,298</td>
</tr>
<tr>
<td>dr.med., specialist, subspecialist, PhD</td>
<td>2,330</td>
</tr>
<tr>
<td>dr.med., specialist, subspecialist, MSc</td>
<td>2,270</td>
</tr>
<tr>
<td>dr.med., specialist, subspecialist, primarius</td>
<td>2,210</td>
</tr>
<tr>
<td>dr.med., specialist, subspecialist</td>
<td>2,140</td>
</tr>
<tr>
<td>dr.med./dr.med.dent., specialist, primarius, PhD, in hospital/state health institute</td>
<td>2,279</td>
</tr>
<tr>
<td>dr.med./dr.med.dent., specialist, primarius, MSc, in hospital/state health institute</td>
<td>2,182</td>
</tr>
<tr>
<td>dr.med./dr.med.dent., specialist, primarius, in hospital/state health institute</td>
<td>2,085</td>
</tr>
<tr>
<td>dr.med./dr.med.dent., specialist, primarius, PhD</td>
<td>2,153</td>
</tr>
<tr>
<td>dr.med./dr.med.dent., specialist, primarius, MSc</td>
<td>2,056</td>
</tr>
<tr>
<td>dr.med./dr.med.dent., specialist, primarius</td>
<td>1,969</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., specialist, PhD, in hospital/state health institute</td>
<td>2,153</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., specialist, MSc, in hospital/state health institute</td>
<td>2,056</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., specialist, in hospital/state health institute</td>
<td>2,027</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., specialist, PhD</td>
<td>1,988</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., specialist, MSc</td>
<td>1,959</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., specialist</td>
<td>1,940</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., resident</td>
<td>1,659</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., PhD</td>
<td>1,804</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm., MSc</td>
<td>1,727</td>
</tr>
<tr>
<td>dr.med./dr.med.dent./mag.med.biochem./mag.pharm.</td>
<td>1,659</td>
</tr>
<tr>
<td>health worker, in health institute</td>
<td>1,659</td>
</tr>
<tr>
<td>mag. logoped.</td>
<td>1,571</td>
</tr>
</tbody>
</table>
 medical physics is explicitly classified science (i.e. biophysics and medical physics; also biochemistry and medical chemistry) but biomedical engineering is not (ex. bioengineering and medical engineering)

there are no (under)graduate university studies in medical physics or biomedical engineering, only postgraduate university (PhD) study in medical physics and university study courses related to biomedical engineering

pre-Bologna „graduate engineer” academic titles in natural, technical, biotechnical and biomedical and health sciences, post-Bologna engineering titles only in technical and biotechnical sciences
medical physicist and biomedical engineer are not regulated professions (no defined standards of qualifications and standards of occupations; no professional acts and/or chambers)

medical physicists and biomedical engineers are supposed to be again explicitly defined as health professionals after 25 years

there are no formal opportunities for continuing professional development and career advancements (internship, residency/specialization, sub-specialization, postgraduate specialist university study, etc.) for medical physicists and biomedical engineers vs. health workers

medical physicist and biomedical engineer (salary) coefficients of job complexity are at the bottom of the scale of clinical staff (graduated from different university studies of equal duration in years and/or workloads in ECTS credits)
SUMMARY

- There are some regulations on medical physics departments and staffing needs in healthcare facilities but no regulations at all for clinical biomedical engineering departments and staffing needs in healthcare facilities (criteria?: number/type of medical devices, medical procedures, patients, hospital departments and personnel, hours of users training and continuing professional development, population, number of beds, etc.=> legislation: health care quality, medical products, metrology, radiation protection,...)

- No involvement/employment of biomedical engineers and medical physicists in national health technologies policies makers [ministries, state agencies, institutes etc. - regulation, health technology assessment, health technology management, research&development and innovations, nomenclature, local/national inventories,...)
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