

POSSIBLE APPLICATIONS OF STATISTICAL METHODS IN ANALYSIS OF A PERIOD OF TIME IN THE EVOLUTION OF ROMANIAN MILITARY PHARMACY

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Abstract

Pharmacists together with physicians had and still have an important role in maintaining public health. Over time, the education of military pharmacists had experienced significant qualitative changes: post graduation courses, military medical courses and so on. Military pharmacists had conducted an extensive activity in science and research, in parallel with their professional activity.

In this paper we described from a qualitative and quantitative point of view, figures / generations of military pharmacists during the reign of Charles I in Romania (1866-1914).

Data obtained from consulted materials were processed using mathematical methods in order to determine the degree of system organization between 1876 and 1905.

The obtained results have demonstrated the possibility of using some mathematical indicators in social studies. We consider that these values could characterize the evolution of Romanian pharmaceutical higher education in the analyzed period.

Rezumat

Farmaciștii împreună cu medicii au avut și au un rol important în menținerea sănătății publice. De-a lungul timpului, pregătirea farmaciștilor militari a cunoscut importante schimbări calitative: cursuri de perfecționare, cursuri medico-militare etc. Farmaciștii militari au desfășurat și o bogată activitate științifică și de cercetare, în paralel cu activitatea profesională.

În această lucrare am urmărit o descriere calitativă și cantitativă a unor figuri/generații de farmaciști militari din perioada domniei lui Carol I (1866-1914).

Datele obținute din materialele consultate au fost prelucrate folosind metode matematice în scopul determinării gradului de organizare a sistemului în perioada 1876-1905.

Rezultatele obținute au demonstrat posibilitatea utilizării unor indicatori matematici în studiile sociale. Considerăm că aceste valori ar putea caracteriza evoluția învățământului superior farmaceutic românesc în perioada analizată.

Keywords: military pharmacy, entropy, complexity, divergence

Introduction

Military pharmacy is, by analogy with “military medicine” [12], a profession practiced by pharmacists enrolled in the army. Military

pharmacists prepare, dose and distribute the needful medicines, dressings and other medical supplies.

Knowledge about the past of the Romanian pharmacy and its natural relationship to universal history of pharmacy are reflected in the evolution of the military pharmacy. Social, economic and political changes that had occurred in society throughout history have influenced the military pharmacy.

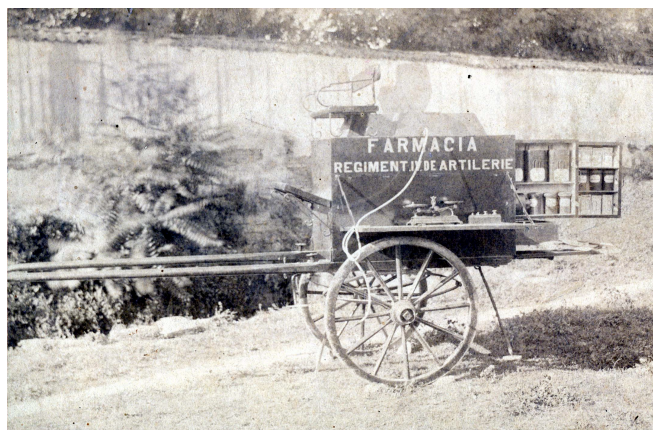


Figure 1

Pharmacy Regiment 4 Artillery Iassy 1883



Figure 2

Pharmacy of Guben Prison camp

Numerous attempts were made [3, 9, 11], to determine general measures associated with the complexity of processes. New methods were introduced for data analysis, that have proved to be useful in various fields such as: Shannon entropy, complexity and divergence statistics [3, 7, 9, 13].

In this paper we used mathematical and physical methods applied for data series in a certain period of time.

The aim was to observe qualitative and quantitative aspects of the professional evolution phenomenon for ranks of Romanian military pharmacists, that graduated between 1876-1906.

Materials and Methods

Data, concerning military pharmacists graduates from Bucharest, were obtained from the *Yearbook of people who have obtained university degrees in the country during the 40 year reign of His Majesty King Charles I (1866-1906)* [14].

We have analyzed data using 3 quantitative statistical measures: Shannon entropy, complexity and entropy-based divergence.

Shannon entropy (H) is a measure of the missing information [13], which can be used for completely random systems (our case) and for perfectly ordered ones. It is calculated based on the relative frequency of recordings.

$$H = -\sum_i v_i \cdot \log_2 v_i$$

H – Shannon entropy

i – data

v_i – frequency for each i

Variation of levels for observed data involves distinction between structures of processes. Taking into account the structure and possible correlations, "disequilibrium" (D) was introduced as a measure of complexity, more suitable to use in evaluating the collected data.

"Disequilibrium" (D) can be defined, in Physics and Mathematics, as a quantity which measures the distances from statistical variables evenly distributed [2]:

$$D(Y) = \sum_{y=1}^n \left(P_r(y) - \frac{1}{N} \right)^2$$

D – disequilibrium

N – total number of data

Y – set of values

y – statistical variable from the set of possible values

Statistical complexity was calculated as a function of Shannon entropy and disequilibrium using the following formula [3, 11]:

$$C_{LMC}[Y] = H[Y]D[Y]$$

$$C_{LMC}[Y] = \text{Complexity Lopez - Ruiz, Mancini, Calbet}$$

$$H[Y] = \text{Shannon entropy}$$

$$D[Y] = \text{Disequilibrium}$$

Divergence which is an entropy-based measure was successfully applied in various scientific fields [7, 9]. This segmentation method can be used to detect borders in which the trend changes.

Jensen-Shannon divergence is defined as:

$$D_{JS} = \max_i D_{JS}(i) = \max_i \left[H - \frac{i}{N} H_L - \frac{N-i}{N} H_R \right]$$

H = Shannon entropy of the whole sequence

H_L = Shannon entropy for left side subsequence of the partition point

$D[Y]$ = Shannon entropy for right side subsequence of the partition point

N = Number of symbols in whole sequence

Results and Discussion

Taking into account the above described methods, the following results were obtained. Data collected in each year indicated 6 groups of military pharmacists: civilian pharmacists, auxiliary, second lieutenant, captains, majors and lieutenant-colonels. Because of the reduced number of data in each category, we merged some of them in order to obtain significant statistical information. Thus we have divided the number of graduates employed in the army in 3 groups: 26 civilian pharmacists, 31 captains and 19 majors and lieutenant-colonels.

In the chart below we reproduced the trend of distribution for graduates in pharmacy.

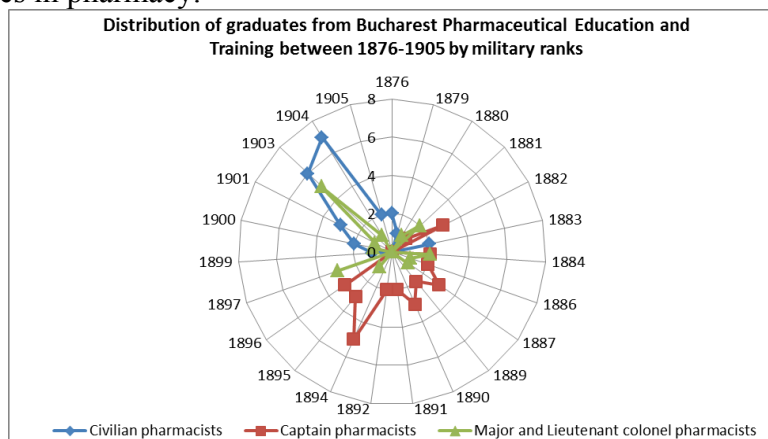


Figure 3

Distribution of Bucharest Pharmacy graduates by military ranks

The number of civilian pharmacists can be characterized in terms of evolution as follows: -1876-1879 downtrend (after the first Romanian Health Law in 1974 [1]), -1880-1882 null constant behavior, -1883 scarcely, graduates enrolled in the army, - after 1900 linear uptrend, -1903 and 1904 inflection points with a lower growth rate.

We noticed that the yearbook was published in 1906 and couldn't include all possible data (including 1905) probably, due to problems of data access and communication.

Regarding captain pharmacists, from the above chart, we observed 3 points of relative maximum (years 1882, 1887, 1890) and also an absolute maximum in 1894. This suggests a growth in the numbers of captains. We observed an oscillatory behaviour.

Data concerning majors and lieutenant colonels pharmacists present an upward trend in 1881, 1884, 1897 (note 3 points of growth) and an absolute maximum in 1903.

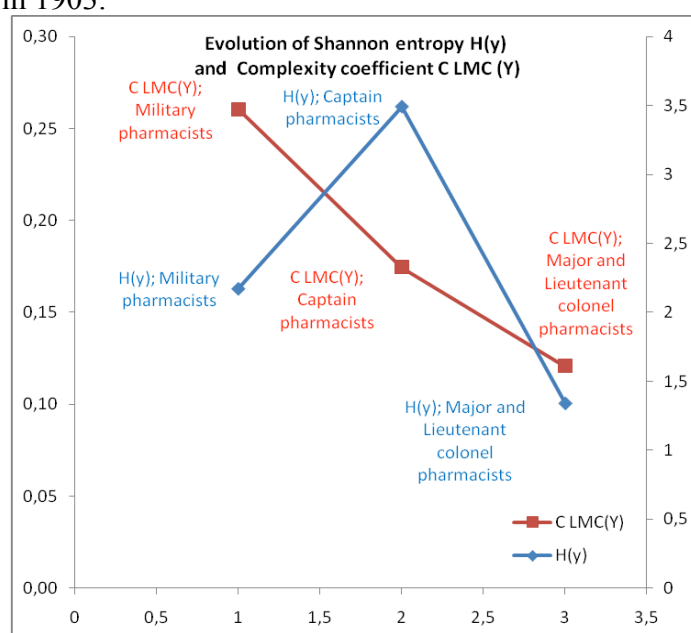


Figure 4

Trends of Shannon entropy and Complexity coefficient for enlisted pharmacists graduates

The highest value of entropy (figure 4) was for captain pharmacists. This can be explained by the oscillatory behaviour, in which the number of captains varied.

The complexity values indicated a downtrend.

The complexity for the civilian pharmacists was the highest, because their evolution knew 5 phases. Simultaneously, it was minimal for majors and lieutenant-colonels, with only 2 periods: one with a single structure represented by 3 equal relative maximum and a second one with an absolute peak.

In the chart below we plotted differences for the three groups of military pharmacists. We applied the divergence method to highlight more clearly important periods in the development, from a statistical point of view. We divided the period 1876-1905 into 2 segments. The cutting point was variable. We represented the divergence by taking into account the total entropy (for the whole period) and each of the 2 segments (Jensen-Shannon divergence formula). We obtained a peak, which indicates that in that year the two segments / periods (right and left) are the most different.

In the chart below we plotted the divergence for the 3 groups of military pharmacists.

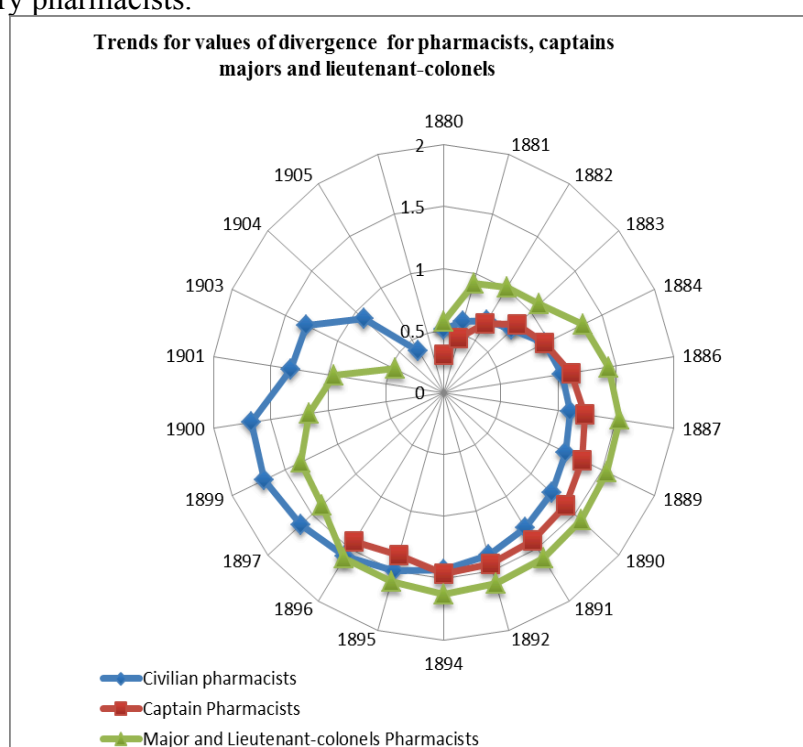


Figure 5

Divergence values for enlisted pharmacists graduates from Bucharest

For the civilian pharmacists the cutting point is year 1900 and the 2 periods that differ statistically significant are 1880-1900, respective 1900-

1905. Until this year the growth was almost linear (they enrolled about the same number per year). A decrease followed.

The maximum divergence for captain pharmacists was recorded in 1894. The values raised gradually, not linear which can be explained by a process that is limited (saturation process that is probably due to society stabilization).

In case of majors and lieutenant-colonel pharmacists a saturation and cessation period was also recorded. The period of maximum was narrow: 1895-1897.



Figure 6-7 Old pharmacy instruments



Figure 8 Inside a military pharmacy, 1917

Although positions in the Army Health services and in the Military Fleet occurred, their numbers were small. In 1897 there was a great migration of personnel, probably a reflow of military pharmacies. This explains the later reduction/drawback of divergence.

We observed similar behavior for superior military officers. This underlines that promotions are probably similar.

In the next chart we plotted military pharmacists distribution as division, battalion, military corps and regiment.

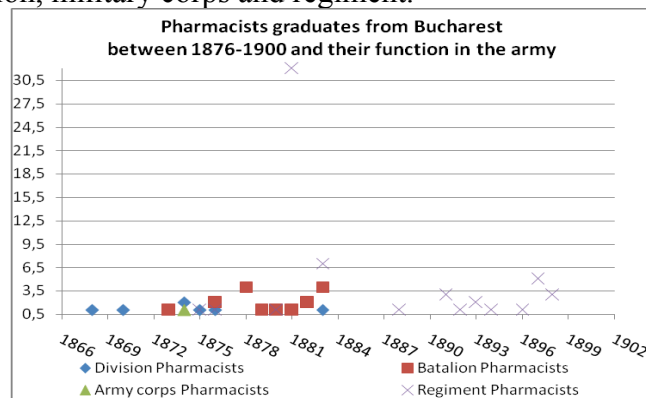


Figure 9

Distribution of Bucharest Pharmacy graduates by 4 military ranks

For division pharmacists we observed a peak in 1874, two periods of constancy and a relative maximum in 1883.

Values for battalion pharmacists showed 2 peaks (1878 and 1883), a minimum period (standstill between 1879-1882) and a relative maximum 1876.

Between 1876-1905 there was only one army corps pharmacist.

In the year of coronation of Charles I (1839-1914) as king, 1881, the number of regiment pharmacists was the highest (between graduates). Then comes an oscillating period flanked by 2 peaks 1883 and 1897.

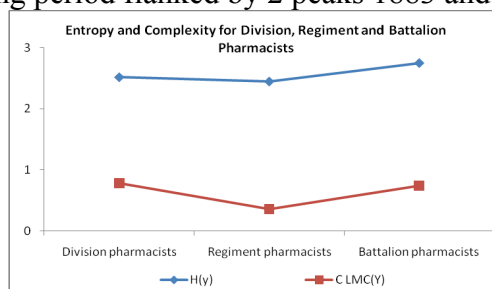


Figure 10

Shannon entropy and Complexity coefficient tendencies for enlisted pharmacists graduates

We observed (figure 10) that entropy and complexity vary in a similar pattern. Complexity is smaller due to the behavior like a concave curve (not very obvious) of disequilibrium. Value of disequilibrium is lowest for regiment pharmacists, because, in all periods their number varies little. Larger variations in the number of division and battalion pharmacists causes an imbalance higher than for regiment pharmacists, but smaller than 1.

We plotted values of divergence for division, battalion and regiment pharmacists (Figure 11).

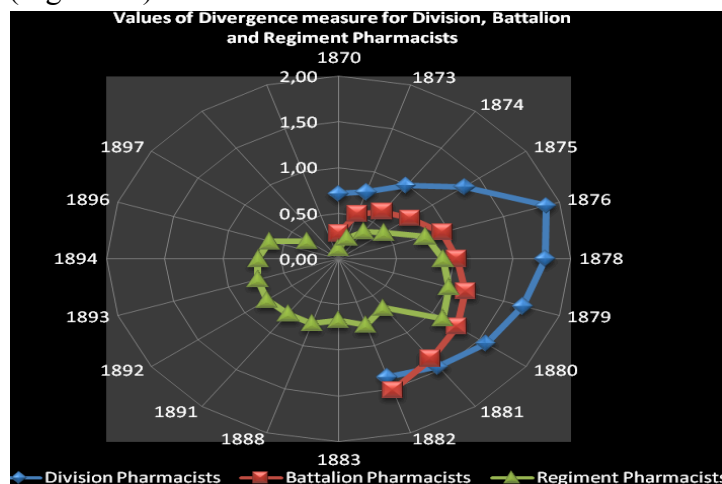


Figure 11

Divergence values for Division, Battalion and Regiment pharmacists

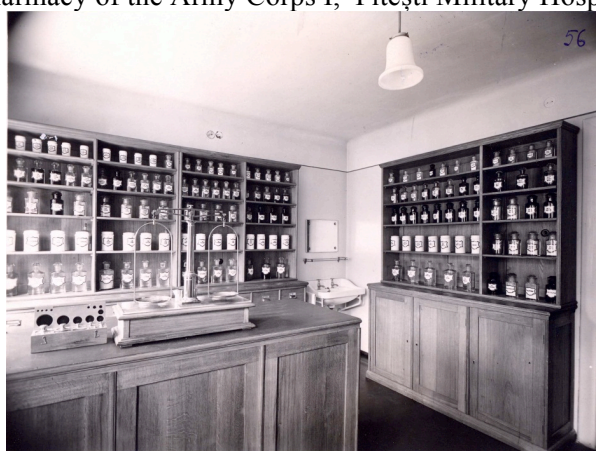
According to divergence values, 1876 was the year when a peak was recorded. Between 1870 and 1876, for division pharmacists, an exponential growth (parabola) was observed. Starting with 1878 (until 1898) there were no known graduates that become division pharmacists [14, 15].

For battalion pharmacists the rise of divergence is relatively linear, with maximum values in 1882. It was promulgated the *Law on Organization of the Army Medical Service* which determined the development of the structure of military pharmacies (therefore entropy components grew and from following year divergence decreased) [5,12].

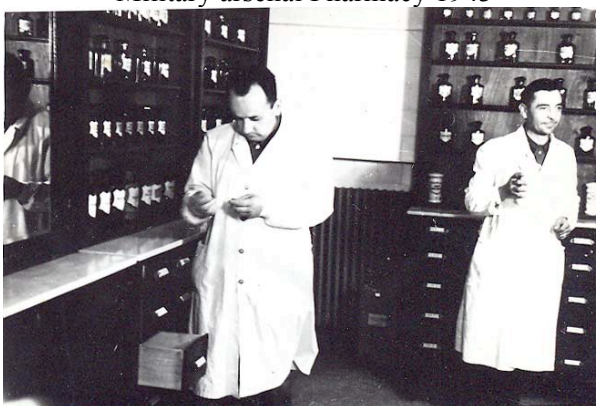
Values of divergence increase almost linear for regiment pharmacists until 1880, when they become maximum. This rise can be correlated with the growth of military personnel number. Decrease of values of the divergence can characterize the entry of society into an increasingly stable period.

**Figure 12**

Pharmacy of the Army Corps I, Pitești Military Hospital

**Figure 13**

Military arsenal Pharmacy 1943

**Figure 14**

Military pharmacy 1940/1950

In the second part of the paper, we present military pharmacists that graduated from the School of Pharmacy in Bucharest between 1876-1906.



Figure 15

Pharmacists Head of the Army from Ministry of Defense 1837-1945

Constantin Cholet (1852-?)



Photo 10

Constantin Cholet [4]

Cholet Constantin was born in Bucharest on 2nd October, 1852. At age 14 he entered the National School of Pharmacy. He graduated in 20th December 1880.

Professional experience

In 1874 (16th April) he was promoted as Battalion Pharmacist.

He obtained the all hierarchical military ranks. In May 1883 he became a Regiment Pharmacist.

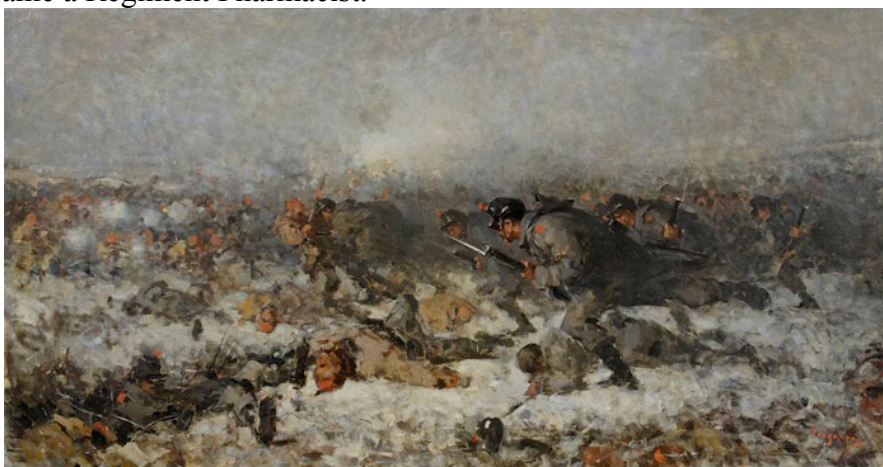


Figure 16

Nicolae Grigorescu (1838-1907) – Smârdan attack

After the Independence war, he worked at Military Flotilla in Galați.

In 1896, as Major, he manages the Chemistry Laboratory established in Galați, together with physician Colonel Șerban Georgescu.

Four years later he was confirmed Major and was named Expert Chemist. In 1904 he was head of the Surgical Warehouse and promoted as Lieutenant-Colonel.

Contribution in Studying flour, bread and biscuits used in Romanian Army, Bucharest, was the title of the thesis presented at examination for obtaining the rank of Army corps pharmacist, by division pharmacist C. Cholet, Bucharest 1891 [2].

He was Pharmacist Head of the Army from 1903 to 1905, when he retired. He was decorated with the order Romanian Star.



Figure 17. Cholet. C [5,6]



Figure 18. Military Order Romanian Star

Throughout his career he was noted both as a good pharmacist (being well trained professionally and up to date with scientific developments of the time) and a good officer.

Merișanu Constantin (1864-1931)



Figure 19

Merișanu Constantin graduated in 1887. [5]

Professional experience

He was Regiment Pharmacist and worked in Chemistry Laboratory, Department of Pharmaceutical Analysis and Military Hygiene. The lab consisted of 3 departments; the other two were Department of Pure Chemical and Forensic Biological Analysis and Department of Microbiology and Experimental Pathology.

In 1897 was a member of the Editing Committee for the Military Health Magazine, together with colleagues from regiment (2 physicians, 1 regiment pharmacist), division (1 pharmacist and 3 veterinary) and army corps (3 physicians, 1 pharmacist and 1 veterinary), according to the regulations in the Order of Ministry of War no. 196 of May 26, 1897.

This Journal was created by doctors, pharmacists and veterinarians at general physician Alexandru Demosthen celebration (born in 1845 in Brăila, became Main Surgeon of the Central Military Hospital and, in 1883, Profesor of Surgery and Topographic Anatomy at Faculty of Medicine) when becoming a corresponding member of the Medicine Academy in Paris, on January 12th 1897.

The magazine included varied original articles, essays on the work of foreign armies health services, the foreign press reviews, news about the life

and work of hospitals and physicians military participation in national and international medical congresses. It focused on the main issues of morbidity in the army and organizing anti-epidemic fight, military law.

In June 1900 Captain C. Merișanu was selected as librarian for the Military Corps Scientific Society. As Colonel Pharmacist he presented in 1912 the paper *A practical and safe way for obtaining sterile water*, at the VIII-th Congress of Romanian Association for the Introduction and Spread of Sciences [8].



Figure 20

Romanian troops in Transylvania, 1916



Figure 21

Romanian troops at Mărășești battlefield in 1917

After the first world war (1914-1918) he lead the Military pharmacy (in Bucharest), subsequently followed Col. Pharm. Constantinescu G., Cernea

I., Vătășanu C., Grițescu Gh., Dr. Ionescu-Matiu Al, Col.Pharm. Popescu F.

Gheorghe Grițescu (1878-1956)

He graduated Pharmacy in 1903. Between 1929 and 1937 he lead the military pharmacy in Bucharest.

Professional experience

Grițescu contributed to the development of networks of pharmacies and laboratories of biochemistry and chemistry at military hospitals, and the workshop for tablets, ampoules and dressings.



Figure 22
Gheorghe Grițescu[5]



Figure 23
Heads of *Carol Davila*
Pharmacy



Figure 24
Pharm.col. Merișanu Bust
Military Central Hospital,
Bucharest, Collection of
General Dr. Pharmacist
(Gh.P.Grițescu)

In 1931 he presented a paper entitled *Methods of preparation, sterilization and storage of ampoules*, at the 6th Pharmacy Congress in Hagues [5].

He was Head of the Pharmaceutical Directory (1937). He participated at the uncovering of the Colonel Pharmacist's Constantin Merișanu Monument.

In 1935 he conceived a new model of portable pharmacy, composed of two large boxes. This model was carried out one year later, in 1936.

He published *Culture and harvesting of pharmaceutical plants*, Pharmaceutical Botany, in 1936 and collaborated at the Military Medical Journal [4].

Conclusions

In this paper we demonstrated that statistical measures can be applied in assessment of time periods and graduates of pharmaceutical education.

Values of entropy characterized the degree of organization, the system structure (it was proved that entropy rises with the growing number of captain pharmacists). Disequilibrium showed the distribution of pharmacists compared with a uniform distribution. Complexity for military pharmacists has grown with the number of stages of system organization and, at the same time, with distance from random behaviour (increasing values towards 1).

Measuring divergence for military pharmacists groups showed trend change points in the evolution of system within each group (1895-1897 for majors and lieutenant-colonels, 1882- battalion pharmacists). It characterized the development of system structure (through employment, promotion, legislative changes) as well as the distribution of pharmacists in each period.

Military pharmacists graduates from Romanian higher education had important scientific contributions evidenced by their scientific research papers presented and published, leadership positions (Pharmacist Head of the Army, Head of the military pharmacy, Head of Pharmaceutical Directory), obtained prizes granted by the Romanian Academy and medals (National Order Romanian Star).

In conclusion we can say that military pharmacists contributed to the development of science and culture in Romania.

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