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General Information

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Brief Description of Research Topic:

System Dynamics (SD) model for the analysis of socio-economic effects after the wide implementation of the ELIP test diagnostic technology. SD applications in the medical field (pre-clinical diagnostics).

Key Words: system dynamics, medicine, systems engineering, ELIP test, pre-clinical diagnostics

2. Thesis Proposal

System Dynamics Model for the Analysis of Socio-Economic Effects after a Wide Implementation of the ELIP-test Diagnostic Technology.

The research area or sub-area of your work: A set of SD models and specific guidelines for the development of the SD applications in the medical field (pre-clinical diagnostics).

The problem to be solved: the importance or relevance of the problem should be justified.

This is an applied research attempting to model a medical test using system dynamics. In fact, the purpose of this work is to develop a set of the SD models for the analysis of socio-economic effects after the wide implementation of the ELIP test diagnostic technology (see the description below), which would allow to show the effectiveness and the necessity of the given test not only from the medical perspective but also from the socio-demographic and the economic ones.

System Dynamics has been applied in medicine however, there are rather few examples and working models demonstrating the effectiveness of the method. Since medical diagnostics is a field of a high risk and precision, it is very important to have models that can represent the situation in the best way possible to help guide the decision makers. So far the penetration of system dynamics into the medical field has been very slow due various reasons: the issue of complexity, the lack of collaboration between the SD and medical research communities, and the lack of models in place which actually show that system dynamics can be beneficial for building the medical models.

In addition, this research attempts to outline how system dynamics fits within the systems engineering framework and present a set of specific guidelines for the SD model development in the field of medical diagnostics. This is an interesting interdisciplinary study with an enormous potential for future applications and further developments in the field. I hope this work will serve as a catalyst for more initiatives to bring the much-needed SD applications into the medical research.

Why the model of pre-clinical diagnostics is needed at all?

Pre-clinical diagnostics is a breakthrough innovation – this is a crystal ball of medicine, of which people dreamed about for centuries. Today we are getting better at monitoring our health however, it's not a common habit. Majority still goes to see a doctor only when they feel sick. Usually, it's already too late, the disease by that time quite often is in the state of its apogee and the treatment becomes costly and sometimes ineffective. This mentality of patients dominates

the world to a different degree in different countries. It will be very difficult to change this and persuade people to check their health on the regular basis to avoid such diseases as diabetes, cancer, etc. Secondary factors which are also extremely important and are not any easier to challenge are the healthcare industry, physicians, health insurance providers and the pharmaceutical corporations. It's obvious that all of the above will rightly oppose the pre-clinical diagnostics entering into our lives as a common procedure. Pharmaceuticals will be losing a lot of money since the demand for their products will fall dramatically and only those drug companies that manage to refocus their activities on producing the necessary drugs will survive. Physicians will have to adjust dramatically their tasks and take on new roles when they communicate with patients. Health insurance will have to be rethought and recalculated to meet the needs of a new healthier society.

Having a working simulation will serve as an endowment for dealing with the above issues. It would be a qualitative and a quantitative proof supported by the actual field test results, patents, scientific papers and happy patients. Nevertheless, it'll take decades before we overcome most barriers on the way to a more effective healthcare. But the first step is crucial – thus this model is of a revolutionary importance.

The research hypothesis (claim) and details of the proposed solution.

This particular research on the example of the ELI-P-test shows the benefits of pre-clinical diagnostics. In turn, it is possible to build models of other similar tests, using the same techniques and then, by putting these tests together, create a system representing the entire scheme of pre-clinical diagnostics. The importance of this work is to lay out the ground for a large scale project of building models for pre-clinical diagnostics to make it more understandable and thus acceptable by the population.

Pre-clinical diagnostics is a method of detecting a disease before its clinical manifestation. Today, the scientists in Russia have already developed various tests allowing to detect the disease before a patient feels an actual sickness or before conventional diagnostics registers abnormalities. This is a novel approach in medicine, which promises to bring revolutionary changes to the healthcare industry, have an economic impact on the society and improve the socio-demographic situation.

This research focuses on one of the tests developed by Moscow scientists at the Immunculus Research Laboratories. ELI-P-test is a method of pre-clinical diagnostics used to determine the probability of pathology in pregnancy. The set of SD models, built in STELLA®, is designed to show the effectiveness of the test from the medical, socio-demographic and economic perspectives. This approach allows to demonstrate how pre-clinical diagnostics influences different instances of our society.

This research attempts to illustrate the applications of simulation methods in medical research. The dynamics in this field has certain specifications, which have to be considered. By summarizing some of these methods, this work

establishes the basis for the development of more sophisticated dynamic models of medical tests for pre-clinical/clinical diagnostics.

Research method

First, I develop casual loop diagrams for all my models and define relationships between the elements. I consult with the Immunculus researches to verify the logistics of the model on paper.

Second, I am using STELLA® to build my computer simulations. In order to build the actual model of the ELIP test, I'm using available and verified data from the Russian studies. When the model shows the desirable results, for initial data I'm entering the US parameters and observe the model's behavior. This approach gives me a high degree of confidence that the model built using the US data produces good results predicting how the application of the ELI-P-test in the US can influence the birth rate of healthy children and decrease the number of births with pathologies, miscarriages and deaths.

The socio-demographic and economic models are built using the US data from the publicly available sources. Models are tested for verification of the results using the sensitivity analysis and the expert evaluation.

Third, the results are interpreted separately for each test and the conclusions are given in each field of study: system dynamics, medicine, socio-economics. Then, the results are combined to make final conclusions of this research and derive the methodology for developing simulations in pre/clinical diagnostics.

The expected contributions of the dissertation research, both theoretically and practically.

This is an applied research, the results of which are anticipated to be used by scientists from both fields – medicine and systems dynamics.

A working SD model of pre-clinical diagnostics test can show how dramatically healthcare industry's performance and operations can be improved. Besides building a model of a medical test, this work defines a set of specific dynamic modeling approaches for building medical diagnostics simulations. By outlining the techniques used and comparing my model to other dynamic models in similar fields, I attempt to produce a generic recipe for building system dynamics simulations for pre-clinical/clinical research.

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The primary contributions of this work:

1. Demonstration of the effectiveness of the one of the new pre-diagnostic methods - the ELI-P-test (medical, economic, socio-demographic). More specifically, I anticipate to forecast the following:

- Number of lives saved (higher birth rate)
- Improved female health (decrease in reported cases)
- Improved child (future adult) health (decrease in reported cases)
- Money saved
- –Treatment of children with pathologies decreases
- –Savings for insurance companies
- –Productive population increases
  Etcetera

2. Demonstration of the effectiveness of the dynamic modeling approach
3. Specification of SD modeling techniques for medical diagnostics.

The secondary contributions of this work:

1. An example for building models of other pre-clinical diagnostics tests (which can be applied and marketed separately).
2. Guidelines for building SD models in the medical diagnostics field.