SOCIAL INFORMATION SYSTEMS IN PUBLIC HEALTH: EMPIRICAL EVIDENCE IN BRAZIL

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ABSTRACT
Public health systems have been cited as complex in several recent studies. At the same time, information systems are discussed from a strictly technological perspective to separate from a social context in which they are inseparable. In addition, there is a lack of studies in the literature about the implementation of these systems in environments that aim at social innovation. To study these relationships, this study aims to answer the following question: What are the relationships / influences between the Social Information System, Public Health and Social Innovation? Thus, the purpose of this research is to develop an analysis model of the relationship between the studied constructs and apply it to the reality of the Neonatal Screening Program of the State of Minas Gerais (PTN-MG). For this, the study was applied within the SUS, in Minas Gerais State, using the 15-year database of the program. To test the relationships between the model constructs, the statistical techniques of multivariate data analysis were used. As main results, it is confirmed that health care networks are configured as complex systems that require information systems with characteristics that adhere to this concept. In addition, it is noted that the information system is a fundamental pillar in social innovation in health, as it has shown a significant relationship with the reduction of health problems and with the PTN-MG quality indicators. From this model tested new, others will emerge indicating the scientific and social contribution of this research, organized in papers.

KEYWORDS
Social Information Systems, Complexity Theory, Public Health, Social Innovation

1. INTRODUCTION
Health care is described in the literature as complex adaptive systems, where there is interdependence between the actors involved promoted by interconnectivity, that is, the action of an actor can broadly influence the other connected actors (Begun et al., 2003). Therefore, a system can be understood as "complex" when the interdependencies that define it also makes it highly dynamic, alternating between periods of stability and chaos.

Adhering to this complexity, the principle of integrality of the SUS makes it necessary to aggregate actions - including health promotion, disease prevention, treatment and rehabilitation - to allow an integration between the different areas that influence the health of the individual (Brasil, 2018). Thus, the health system has multidimensional characteristics due to its interaction with other sectors of society, which has a direct or indirect impact on the health-disease process, suffering and causing transformations in the context of the ethical, ecological, epidemiological, strategic, educational, transcendental, economic, political and psycho-socio-cultural dimensions of the health sector (Chaves, 1998).

At the same time, health care has also been the focus of research by the Centre de Recherche sur les Innovations Sociales (CRİSES) ¹ from the point of view of Social Innovation. Martinelli et al. (2003) show that social innovation, in its product and process dimensions, is characterized by at least three forms of

¹ Canadian interuniversity and multidisciplinary organization founded in 1986 and a pioneer in the studies of social innovation. It is formed by the Universities of Québec, Laval, Concordia, School of High Commercial Studies of Montreal and the National Institute of Scientific Research - Urbanization, Culture and Society.
achievement, alone or combined, carried out through some form of collective action: a) contributes to meeting human needs not considered/satisfied; b) increases access rights; c) increases human capabilities.

Recently, several studies on social innovation have been carried out, however, the literature shows the complexity about this concept (Edwards-Schachter and Wallace, 2015). There are difficulties in the elaboration of indicators that allow to explain empirical phenomena related to the theme (Castro-Spila and Unceta, 2015; Unceta et al., 2016).

In the health context, social innovation is understood to be necessary to promote the development of new medicines, vaccines, and essential diagnoses, in addition to helping in public and private efforts to maintain essential services and promote health at the individual and community level (Gardner et al., 2007).

Considering this scenario of complexity to provide social innovation, Information Technology (IT) should be discussed and used to satisfy the conditions of this environment. Thus, the scope of Social Information Systems (SISs) is broader, as it should support and foster the development of social and collaborative skills over time. In addition, they should facilitate the provision of services (e.g., patient in the health system) and develop social skills inherent to these systems (Kuziemsky et al., 2016).

The aim of this study is to empirically test a model that evidences the role of the social information system in the process of social innovation in the health area.

2. METHODOLOGY

The research field of this study is the state of Minas Gerais, located in the southeast of the country and with an estimated population of more than 21,000,000 inhabitants (IBGE, 2017), where we sought to focus on the Neonatal Screening Program of Minas Gerais.

The database used to verify the proposed model was analyzed from 01/2004 to 04/2019, corresponding to approximately 15 years (equivalent to approximately 3,700,000 children screened). The source of these data will be the Center for Actions and Research in Diagnostic Support of the Faculty of Medicine of UFMG (Nupad), which is the reference center of PTN-MG in the state of Minas Gerais.

The model proposed in this article can be classified as exploratory and, from the literature review, Figure 1 is observed that illustrates the proposed research problem: What are the relationships/influences between the Health Information System (Social Information System), PTN-MG and health problems?

![Figure 1. SISs impact assessment model on SI and Health Problems](Source: Prepared by the authors)

Thus, it is intended to quantitatively measure the result of Social Innovation in Health (Health Problems), during the challenges of complexity (Public Health), and to investigate the role of the SIS in this relationship. The factors investigated in this model are based on the literature as highlighted in Table 1.
The factors of the social information system were based on the principles of complexity theory, considering the social information system as part of a complex social system. For this, variables were thought that could indicate adherence to the principles: systemic, hologramic, recursive, autonomy/dependence and retroactive.

The variables SIS3, SIS4 and SIS5 were obtained from the PTN-MG database and accounted for all the actions or feedback functions that the information system had in the period. Self-regulation was considered when the feedback action resulted in an adjustment in the PTN-MG - identified some need and generated automatic correction actions that were successful.

Regarding the factors of the Neonatal Screening Program of the State of Minas Gerais, this study uses variables recommended by the Ministry of Health: coverage of the program, percentage of collections performed at the age considered ideal (up to the 5th day of life), the age of the newborn at the time of the first consultation (for those who presented altered tests in the screening) and the number of collection points for the test in the State. Thus, this construct does not measure the PTN-MG itself, but rather the variables considered fundamental by the Ministry of Health to evaluate the quality and efficiency of the Program.

On the other hand, the factors of Health Problems of the model are based on the metrics found in the literature, specifically for measuring the results of social innovation in health (Nuño-Solínis, 2014; Hean et al., 2015; Grindell et al., 2018; Vechakul et al., 2015; Schiavo et al., 2016; Currie and Seddon, 2014; Bazzano et al., 2017; Mummah et al., 2016; Singh, 2017). In addition, for the application of these concepts in PTN-MG, indicators were pointed out based on the final objective of neonatal screening: "early diagnosis, in a timely manner, so that the necessary interventions allow the reduction of mortality and morbidity for congenital and hereditary diseases of the newborn" (Januário, 2015, p. 7).

The death rates used were related to children who had early outpatient follow-up in PTN-MG. Monthly accumulated rates were used since the beginning of the tests for each disease in order to analyze a longer period for the calculation (above 1 year). Thus, the accumulated monthly rate was calculated as follows for each of the diseases: (number of children who died/number of children under follow-up) x 100. All other variables were also calculated or accounted for month by month from January 2004 to April 2019.

Thus, this study considered program variables that could translate the impact and social transformation, in addition to clear results through the reduction of health problems in the children of the program. From the proposed model, we intend to test the following hypotheses (Figure 2):
Thus, the hypotheses are described below:

- **Hypothesis 1 (H1):** The social information system influences health problems.
- **Hypothesis 2 (H2):** The social information system influences PTN-MG.
- **Hypothesis 3 (H3):** The social information system and the PTN-MG influence health problems.

In the proposed model, it is observed that social innovation (territory type) comprises all constructs. This is because they present themselves as an integral part of IS. For this, this work was based on the dimensions of analysis of The SI of Cloutier (2003) that considers the following items: object (PTN-MG), field (State of Minas Gerais), target (individuals), objective (reduction of health problems), process (multisectoral and interdisciplinary) and result (health problems metrics).

In addition, the Tardif and Harrison (2005) thesaurus represented by social transformation (Table 2) are also considered:

<table>
<thead>
<tr>
<th>Social Transformation</th>
<th>Social Action</th>
<th>Proposal</th>
<th>Institution</th>
<th>Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconstruction</td>
<td>Neonatal Screening Program (Policies and Programs)</td>
<td>Reduction of Health Problems (Common Good, General interest)</td>
<td>Government</td>
<td>Complexity presented by Public Health</td>
</tr>
</tbody>
</table>

Although the SIS is an integral part of the PTN-MG, we opted for separation to better understand its role in both the Program and health problems. In addition, it has been pointed out as one of the main characteristics of IS in health (Wass and Vimarlund, 2015; De Rosa, 2017; Warnecke, 2017; Sliwa et al., 2017). It is therefore intended to confirm this finding.

Thus, the suggested model aims to measure relationships between constructs of the model and the possible influences exerted between them. For illustration purposes, the variables of each construct were represented by its abbreviated name and a sequence number (construct variable 01 "social information system" was named SIS1, and so on).
3. RESULTS

This work made an analysis of the outliers, which are observations that present a different response pattern from the other ones. The univariate outliers were diagnosed by standardizing the results, so that the mean of the variable was 0 and the standard deviation 1. Thus, observations with standardized scores outside the range of [-3.29; 3.29] were considered outliers (Hair, et al., 2009). Based on this criterion, only 9 (0.33%) observations considered atypical in a univariate way. Multivariate outliers were diagnosed based on mahalanobis $d^2$ measurement. According to this criterion, no multivariate atypical observations were found.

The measurement and regression models were performed using the PLS method. This has been referred to as a soft modeling technique with minimal demand, when considering the scales of measurements, sample size and residual distributions (Monecke, et al., 2012). Table 3 presents the structural model.

<table>
<thead>
<tr>
<th>Endogenous</th>
<th>Exogenous</th>
<th>$\beta$</th>
<th>E.P. ($\beta$)</th>
<th>I.C. - 95%²</th>
<th>Valor-p</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonatal Newborn Screening Program</td>
<td>Social Information System</td>
<td>-0.57</td>
<td>0.06</td>
<td>[-0.64; -0.51]</td>
<td>0.00</td>
<td>32.23%</td>
</tr>
<tr>
<td>Health Problem</td>
<td>Social Information System</td>
<td>-0.77</td>
<td>0.04</td>
<td>[-0.82; -0.71]</td>
<td>0.00</td>
<td>82.08%</td>
</tr>
<tr>
<td></td>
<td>Neonatal Screening Program</td>
<td>0.20</td>
<td>0.04</td>
<td>[0.15; 0.27]</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

¹ Standard Error; ² Bootstrap range; GoF = 65.01%.

Source: Prepared by the Author

Thus, it is possible to:

- There was a significant influence (p-value=0.00) and negative ($\beta$= - 0.57 [-0.64; -0.51]) of social information system on the Neonatal Screening Program, so the higher the Social Information System, the smaller the indicator of Neonatal Screening Program will tend to be.
- There was a significant influence (p-value=0.00) and negative ($\beta$= - 0.77 [-0.82; -0.71]) of social information system on health problems, so the higher the Social Information System, the smaller health problems will tend to be.
- There was a significant influence (p-value=0.00) and positive ($\beta$=0.20 [0.15; 0.27]) of the Neonatal Screening Program on Health Problems, so the higher the Neonatal Screening Program, the greater the health problems will tend to be.
- The Construct of Social Information System was able to explain 32.23% of the variability of the Neonatal Screening Program and both were able to explain 82.08% of the variability of Health Problems. In addition, it is worth mentioning that the model presented a GoF of 65.01% (Figure 3).

![Figure 3. Structural Model Illustration](image_url)

Source: Prepared by the Author
It is important to point out that the value $\beta$ shows the strength of relationships. This means that the closer to 1, the greater the influence. The Social Information System had a $\beta = -0.77$ on health problems and was the largest $\beta$ the model. Thus, it represents an influence 3.85 times greater than the indicators of PTN-MG ($\beta = 0.20$) on health problems.

Therefore, of the 82.08% observed in R2 of the model, it can be affirmed that the Social Information System represents approximately 65.16% of the total variability of health problems. PTN-MG represents 16.92% since it has a 3.85 times lower influence.

4. CONCLUSION

This study tries to explain the influence of the information system in a large public health program and, specifically, in the results that this program as a social innovation must achieve.

The results show that PTN-MG is a public health program that is configured as a social innovation, as it managed to solve the problems it proposes, that is, it reduced the mortality rate of the patients involved. The model showed that the reduction in the program’s indicators has a significant relationship with the reduction of health problems over 15 years. In addition, considering that the SISO is part of the PTN-MG, 82% of the reduction observed in health problems can be explained by the program.

It is also noticed that the indicators recommended by the Ministry of Health to assess the quality of programs in the country may be insufficient. This is due to the strength of the indicators' relationship to health problems below the strength observed by the information system (3.5 times less). It is concluded, therefore, that the management of the program is a primary factor to be considered by federal policies regarding neonatal screening. The indicators pointed out by the government represent only part of the measurement.

Another important detail was the significant and negative relationship of the information system with both PTN-MG and health problems, that is, the higher the SISO, the lower the indicators and mortality. This is a valuable contribution, given the weight observed in the relationships between the constructs, as it reinforces that the complex characteristics must be considered when implementing a SISO.

Therefore, as a contribution, it can be emphasized that the results indicate that some factors must be considered in the planning and implementation of health information systems. These data are important so that initiatives, especially social innovation, can have indicators or clear metrics to demonstrate their effectiveness, especially in public policy actions.

As work limitations, it is understood that this study had its research carried out based on a specific health information system in operation in a Brazilian state. As a proposal for future research, the following can be indicated: application of the model in other realities and in other information systems to confirm the relationships identified.

REFERENCES


