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IMPROVING INTERDISCIPLINARY RESEARCH THROUGH EDUCATIONAL TRADING ZONES: A MIXED METHODS APPROACH TO EVALUATING COMMUNICATION PATTERNS BETWEEN PHYSICIANS AND STATISTICIANS

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ABSTRACT

The objective of this study was to perform a qualitative study to identify commonalities and differences in reasoning processes between these groups. A phenomenological qualitative study based on transcriptions of physicians and statisticians conceptualizing clinical cases and clinical research questions. Interviews were carried out with nine statisticians and sixteen physicians contacted virtually. The main outcome measures were emerging themes that were common to both expert groups. Both groups used conceptual models -although different models- during their reasoning processes, but their concepts were not common between the groups complicating the exchange of information. Both groups were unaware that their specialty language was frequently inaccessible to non-specialists or specialists from other fields, which leads to communication difficulties. These difficulties were broadly classified into translational problems of field-specific terms and concepts. Field-specific terms would sometimes lead to misinterpretations while the translation of field-specific concepts often leads to content loss. The use of field-specific terms and concepts can lead to confusion and misinterpretation. Teams would benefit from taxonomies containing terms that can be understood by specialists from both disciplines

KEYWORDS
Communication patterns, educational trading zones, improvement .

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INTRODUÇÃO

A "trading zone" is any kind of interdisciplinary collaboration where two or more perspectives are combined, and so, a shared language develops [1]. Problems in interdisciplinary communication, especially between clinical and statistician languages have been extensively demonstrated in the clinical realm [2]. A survey found 8 of 10 clinicians believed their career would benefit by a better understanding of biostatistics, and only 17.6% believed their training in biostatistics was adequate for their needs [3].

It is important to define the difference between "trade" and "trading zone". A 'trade' is the simple act of exchanging something with limited communication challenges, while a 'trading zone' is defined as locations where communities with challenged communication interact and find solutions to communication obstacles [1]. Although this is an important issue, rarely the perception of trading zones has been explored in clinical settings, especially when discussing statisticians and clinical health professional's interdisciplinary collaboration.

Statistics are and will continue to be a pervasive and important component in biomedical research and healthcare. Therefore, interdisciplinary approaches to clinical care teams can lead to an enhancement of preventive, diagnostic, and therapeutic decisions in a vast amplitude of areas such as emergency medicine or chronic disease management [4, 5]. However, an interdisciplinary approach can be plagued by communication difficulties and conflicts reducing the team's' ability to establish the consensus needed for productive work [6, 7]. Also, problems in interdisciplinary collaboration can diminish the quality of care and lead to medical errors [8].

In clinical research settings with an interface between clinical researchers and statisticians, failure in communication often occurs since clinicians and statisticians "speak" in different and highly technical languages [9]. These conflicts lead to problems in both study design and the interpretation of results. Also the clinician and statistician, may fail to realize the importance of a collaborative effort. Physicians and other health professionals are increasingly aware of their need for biostatistical knowledge, not only if directly involved in research activities, but as a clinical practitioner [10]. However, very often poor communication and collaboration occurs between clinicians and statisticians, even after recognizing the importance of these critical aspects for health studies and practices.

There is a gap in the current literature on the need to comprehend communication patterns in order to facilitate a "trading zone" environment between this two professionals.

Therefore, the aim of this mixed methods study was to qualitatively evaluate patterns in communication between physicians and statisticians in order to understand interdisciplinary communication issues, extrapolating quantitatively to a mediated modeling of the potential improvement of a trading zone approach.

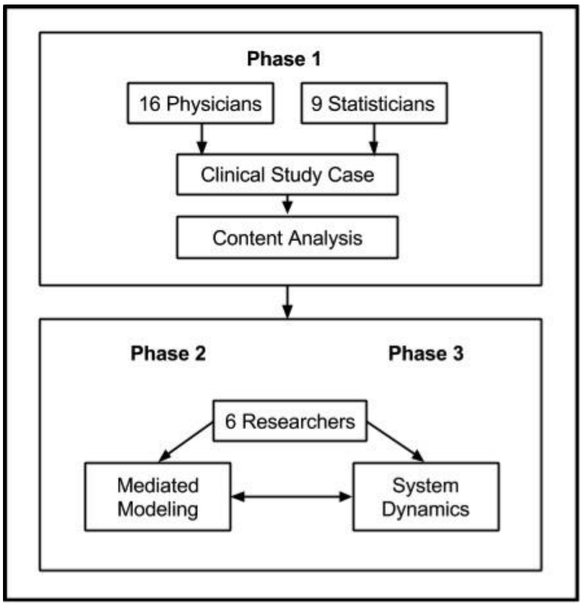
METHODS

STUDY DESIGN

This mixed methods study was designed as a multiphase design [11] with 3 sequential phases two qualitative and one quantitative. For Phase 1, a convenience sample of 16 clinicians and 9 statisticians were selected after responding to an email invitation to participate. A pre-scheduled recorded interview occurred where each professional was handed clinical and statistical cases. The clinicians and statisticians were told to explain the best way to solve the case to the research interviewer. The interviews were transcribed and submitted for content analysis about the patterns of communication problems.

Phase 2 was composed by a mediated modeling approach with 4 researchers with expertise in research process and scientific communication and 2 clinical researchers leading high impact clinic research groups. They were enrolled to generate in an iterative qualitative process of individual interviews a model to simulate a trading zone environment to deal with communication issues between clinical researchers and statisticians. Finally, Phase 3 consisted of a System Dynamics modeling simulation to evaluate the performance of our trading zone environment mediated modeling (Fig 1) [12, 13]

Figure 1 –Study design



Transcriptions were coded with hand coding and RQDA software [14]. System dynamics modeling was performed using the Vensim DSS version 5.11 from Ventana Systems Inc. [15].

ETHICAL STATEMENT

This study protocol was approved by Human Beings Ethics in Research Committee (CEP) of Faculdade Ingá. Written informed consent was obtained from all participants involved in our study. All recorded data was physically destroyed (tapes) or deleted (digital recording) after transcriptions.

Phase 1. Qualitative Study

A phenomenological approach was used in this analysis. The phenomenologic approach attempts to describe phenomena as they present without recourse to previous theory, deduction, or assumptions from other disciplines. Phenomenological methods are particularly effective at identifying experiences and individual's perceptions and elucidate how professionals' interpretations and meanings relate to findings [16].

Recruitment and Research team

During thirteen months, 25 individual interviews of 16 physicians and 9 statisticians were conducted in person or virtually by videoconference. A nurse and biomedicine researcher (NMG, ACO) interviewed physicians and statisticians. Researcher's background include BS, MSc, MD and PhD. All researchers involved in this study are active clinical researchers with an interest in understanding reasoning processes with a goal of improving scientific productivity within interdisciplinary teams.

Prior to the start of this study, none of the investigators had preconceived hypotheses explain the difficulties in communication, although all believed that difficulties exist. Study participants did not know the researchers nor vice-versa at the outset of the research, thereby strengthening data accuracy in the phenomenological approach.

Convenience sampling participant selection was used after resume selection and email contact. Participating Brazilian physicians were on average 34 years old, mostly males (65%), and had been in practice for an average of 8.8 years. Physicians worked at one medium-size private referral hospital for its state. All statisticians worked at an academic institution in the following specialty departments: cardiology (n=4), pediatrics (n=5), surgery (n=6) and anesthesiology (n=1). Statisticians (n=9) were on average 36 years old, mostly male (89%). Our sample included practicing physicians while statisticians were recruited among professors and graduate students working at an academic institution and in charge of providing statistical consulting. None of the recruited participants were excluded or refused to participate.

Data collection

Research assistants (APB, EC, ACO, TY and PC) carried out in-depth 40-60 minute individual interviews and audio recorded them with two electronic recorders. Field notes were taken after each interview. An initial script was created with author consensus and later was updated according to intermediate results after each interview, thus using an iterative approach that allowed us to reach a progressive level of depth in our search for emerging themes.

In order to improve accuracy, all transcriptions were performed verbatim by the interviewers (PC) less than seven days from the original data collection. All transcripts were reviewed for accuracy and were available to other participating researchers. Physician and statistician identifiers were removed from the transcript to ensure confidentiality. Notes and impressions obtained during the interview were added to the original transcription as comments. This research was carried out in Brazil and performed in the primary language of the researchers so quotations used for illustration in this report were translated from Portuguese to English by the authors (JRNV and LC) and independently back-translated by the other bilingual researchers (NMG and PC) to ensure translation accuracy.

Data analysis

Within a phenomenological framework, we analyzed each transcription following three standardized steps: (1) Obtained a sense of the entire transcription through multiple readings; (2) Identified concept categories and extracted the ones that were relevant for the clinical reasoning process; and (3) Integrated different concept categories into an emerging theme. Emerging themes were then articulated regarding their role in the reasoning process as a whole (Fig 1).

The primary author (JRNV) initially coded each transcription, which was later checked and discussed with the interviewers and other participating researchers (LA, APB and EC). All discrepancies were resolved through discussion. Data saturation was achieved from 16 physicians and 9 statisticians, including 20 clinical interview encounters, 16 clinical discussions, and 21 personal interviews.

Theme validation

The transcripts of individual interviews were sent to the participants for comments and alterations. Participants ensured the transcript is a true record of what they intended to say or, where necessary, elaborated or provided a more nuanced perspective.

Phase 2. Mediated Modeling

Mediated modeling is an approach where computer simulation models are used to both synthesize results from qualitative and quantitative results and then communicate them to those involved with the problem being addressed by the model. In our case, models were used to summarize our qualitative results and then communicate them back to researchers interested in interdisciplinary communication so that we could reach a consensus on the relationship among the multiple emerging themes (Fig 1) [17].

Member selection

We used a respondent driven sampling method to recruit members for our modeling group [18]. Initially, we recruited experts in research to participate. Peers were then recruited by initial participants through dual incentive respondent driven sampling. Recruitment ended when saturation was achieved, or when six experts provided input to our model. Participants were from different backgrounds from the state of Paraná, Brazil: 4 research group leaders with research process expertise from 2 leading universities, and 2 clinical researchers and research group leaders involved with randomized controlled trials and epidemiology research at a university hospital. All participants had undertaken research standardization training and applied standardization tools [19].

Data collection and preliminary model development

Similar to Phase 1, 40-60 minute individual interviews were conducted in personal or virtually, and were audio recorded by two electronic recorders. Meeting goals were to discuss potential strategies to deal with communication issues identified in Phase 1. Solutions were then theoretically organized into a framework model of intervention. Field notes were recorded after each interview, with an average of 3 interviews per participant.

All interviews were conducted independently and a final model was developed by aggregating the information provided by each of the six participants. When all participants indicated that no new changes were needed to the preliminary model, a second set of interviews was conducted to validate the theoretical trading zones model and estimate potential changes in the communication process. This part of Phase 2 was concurrent with Phase 3.

Phase 3. System dynamics

We used a System Dynamics (SD) modeling approach in order to understand the professional communication practices and challenges [12]. SD modeling method is commonly used to help to understand the behavior of complex systems. Phase 1 and 2 participants' thoughts and impressions about the problem were translated into a preliminary Causal Loop Diagram (CLD) to visualize interrelated variable affects [12]. Then, the modeling team identified the data requirements and parameters and collected relevant information to build a quantitative model. The model was then fed qualitative data and simulated different scenarios (like worst and best communication environments). Ultimately, various system scenarios were compared to understand their relative differences.

If the model generates a data pattern similar to an observed pattern, it enhances the confidence in a model. The model is then simulated across different scenarios and extreme values to detect unacceptable errors. Participants visually evaluate the comparative graphs to determine the difference between the observed and simulated values.

Finally, each expert received a tutorial and tested the model. We conducted a closing interview and a survey to determine satisfaction and goal achievement. Each expert filled in a survey about the satisfaction, usability, productivity change of the model and standardized tools. The final model was then built and calibrated.

RESULTS

Communication Pattern Issues

Analysis of the collected data yielded two main emerging themes, namely the exchange of language terms and the exchange of scientific instruments. These themes are explored and further dissected below.

Language exchange

Limited awareness or translation of specialty language terms and concepts

Both physicians and statisticians framed the situation they were analyzing with concepts unique to their respective fields. For example, a statistician explaining to the interviewer about the rationale for the analysis stated: "I wanted to use a technique that takes into account the covariance among all variables over time [...] we decided to use ARIMA [referring to Auto-Regressive Integrated Moving Average], [...]" (S1). This introduction of technical terms was unintentional, as can also be demonstrated by a physician's quote "At this particular moment the cardiac enzymes might not be elevated [cardiologist talking about a patient with a heart attack]." (P1). Another example of limited awareness of specialty language was present in an interview with a surgeon: "No, this procedure cannot be done outside the OR" [surgeon to researcher] (P2) "[...] I don't know what that means [...]" [interviewer in reply, since she didn't understand the meaning of "ambulatory procedures"]. (P2).

When confronted with questions about term definitions, both professionals attempted explanations using additional technical terms rather than lay language or non-technical accessible terms. For example, a statistician stated: "Well, this variable (pain score) does not have a normal distribution [...] a possibility would be to turn it into a binomial variable [...] Using a limited number of data would make the results biased, especially due to the abnormal distribution, hence the sample would not properly reflect the population [...] but the model would be simpler if we didn't take that into account" (S2). Or a physician explaining a diagnosis and surgical procedure: "OK, his diagnosis is a congenital stenosis of the aorta and he needs surgery [...] he was born with a condition that [long pause] doesn't let the blood flow freely. [...] we need to do a surgery to resect that stenotic portion and use a graft to fill the gap [patient looks confused]". (P2).

Failed attempts to translate special concepts were characterized by either a lack of an appropriate synonym or an inability to express equivalent concepts in lay language. This differentiation between synonym term and concept was deemed important by our group and lead us to investigate their differences in more depth.

Translation of field-specific words

Translation of field-specific terms was observed when one specialty word is translated to exactly one word from another specialty. A typical comment was "[...] the best measure is the median [...] which is the value in the middle" (S3). This type of translation was more common among statisticians who had performed extensive clinical consulting, and non-existent among physicians.

When evaluating field-specific terms, miscommunication mainly arose when statisticians were expected to know the equivalent clinical synonym term and they misunderstood it. For example, a statistician gave a clinical example to explain a "soft endpoint": "In situations such as a transfusion during a cardiac surgery, a large number of patients have some psychological side effects" [statistician referring to cognitive problems secondary to extracorporeal circulation] (S5). This misinterpretation also occurs when researchers expected physicians to know statistical terms when in fact they misunderstood it: "[...] a statistician previously suggested we begin a case-control study" [Physician attempting to refer to a cohort study] (P3). In another case, a physician confused the concept of missing data with a value of zero: "[…] but the value is missing […] look, the patient, does not have high blood pressure" (P4). This misinterpretation can lead primarily to content modification and confusion to the specialist in the other field.

Translation of field-specific concepts

Concept translation was observed when a concept in the clinical or statistical field could not be translated to a corresponding field-specific term on the language of the other specialty. Instead, the field-specific term was translated to lay language inaccessible to others. For example, a physician, trying to translate a concept of statistical association in a clinical situation, mentions that "[…] open appendectomies may have more complications when compared to laparoscopy" (P5). This pattern was observed among all specialists: Physicians tried to explain technical terms with a language accessible to their patients while statisticians tried to explain technical terms with a language accessible to the clients or the interviewer who had a clinical but not a statistical background.

In contrast with the translation between field-specific terms, the translation of field-specific concepts to lay language was associated with content loss rather than modification. Although this may seem like a lesser problem, in extreme cases the content loss was total, leading to no communication or miscommunication that was carried through several meetings. For example, a statistician explaining why analysis had not been performed appropriately: "[…] when you [physician] mentioned that the heart was lacking oxygen [referring to angina], I interpreted it as an AMI […] now we will have to redo the analysis" (S6) or a data analyst talking with a resident about the concept of survival analysis: "the concept of survival in a survival analysis is not necessarily referring to life and death, it could mean that something that was expected happened within a time frame [...] for example, a patient who was discharged from the ICU on the fifth day" (S7).

Instrument exchange

We observed that interactions between professionals and the interviewer included not only language exchange, but also an instrument exchange used in data collection and presentation. While the physician and statistician instruments are quite different (i.e. spreadsheets, diagnostic assessments/tests) they pervade the communication process as they explain what information is needed and how it is evaluated. For example, when asked about what factors are included in an analysis, a statistician may go directly to a spreadsheet to demonstrate what the variables are and what the type of information they consist of - "Look, these columns are variables" (S8). He implicitly communicates the data format needed for analysis by referring to a data entry process where paper form data must be compiled into a spreadsheet and states, "He is adding the results of the questionnaire to a spreadsheet" (S9). For a statistician, the process of collecting data/information means that it must be compiled in a highly specific format which is communicated by referring to instrument itself (i.e. spreadsheet) and explaining its production and contents. For physicians, instruments consist primarily of diagnostic assessments/evaluations. "This is not really an infection [...] it is more an inflammatory reaction after surgery" (P6).

Qualitative Preliminary model

Based on the interview results, facilitators prepared a causal loop diagrams to elicit individual participant perspectives, resulting in a preliminary model that represented the system as it stands (Fig 2). For example, in the model both emerging themes of communication patterns issues identified earlier enter as areas to improve providing better standardization of communication. The other central node in the model is the difficulty interpreting interdisciplinary data, which influences more difficulties with research conducting overall and incorrect interpretation.

Both ends lead to a pattern of communication and interchange (exchange of experiences) that positively influence (blue arrow) and negatively influence (red arrow). The exchange of experiences between professionals will positively or negatively influence conversion of the difficulty to understand interdisciplinary data into more standardization, closing the causal loop (Fig 2).

Quantitative model session

The modeling team built a quantitative model inserting testing values to simulate a real environment. Input data for the model-involved evaluation of techniques applied by clinical and non-clinical researchers to facilitate trading zones with emphasis on exchange of language and exchange of instruments. Overall, interview results demonstrated that standardized techniques were the most common method to enhance trading zones between physicians and statisticians (Table 1). Clinical researchers used tools (data dictionaries and standardized variables) to normalize translations of themes, provided a consistent definition for key concepts.

Figure 2 -System Dynamics Model representing interaction between statisticians and physicians

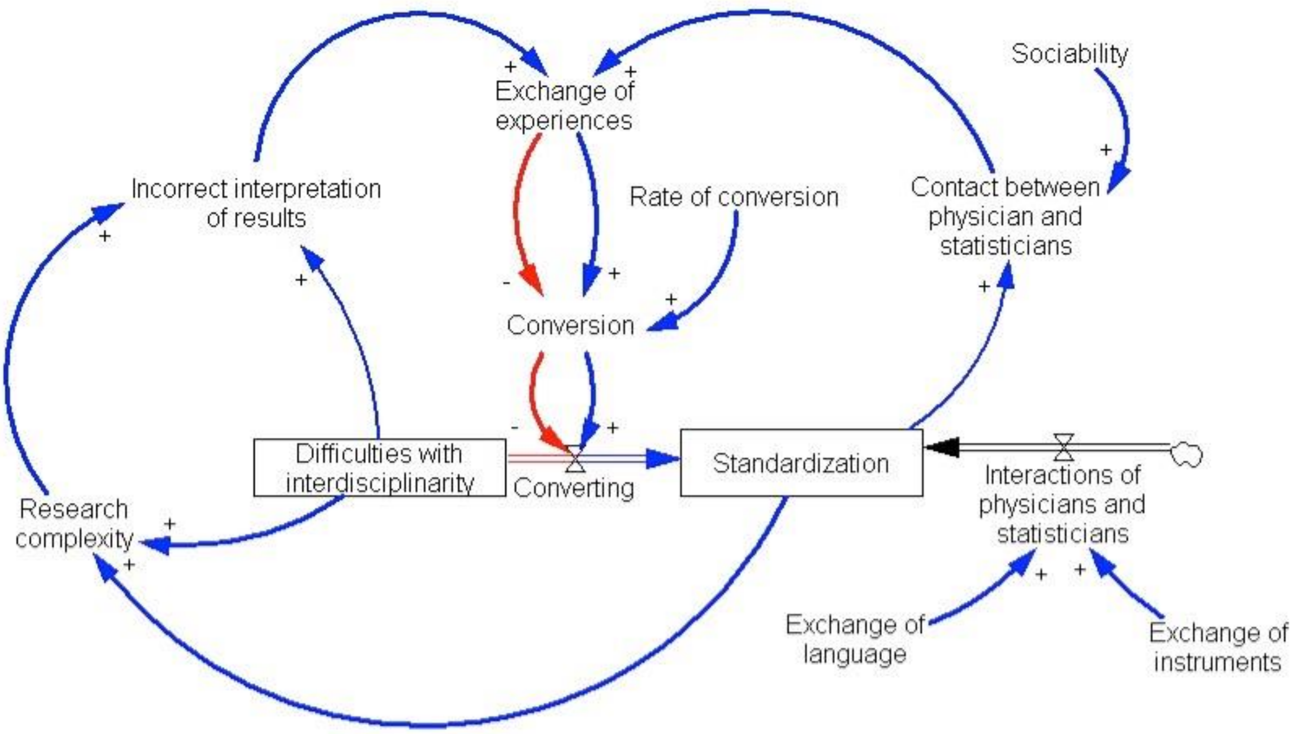


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Table 1 - Trading zones facilitation techniques and tools

	Techniques	Definition
Language Exchange	Access to information	Usage of open collaborative repositories to facilitate access and storage of important trading zones tools
	Access to communication	Usage of tools to facilitate communication such as online chats, organizational structures and group meetings
	Variable standardization	Standardization of terms used in the literature based on international standards
	Standardized definition	Documents with definitions for the key concepts for each project
Instrument Exchange	SOPs and tutorials	Documenta with guidelines, steps and examples of each methods and data analysis
	Templates	Pre-structured examples of writing such as analysis sections.
	Data dictionary	Document with specific information on the variable on the data set including: definition (concept) of the variable, label, metric, type of variable, interpretation.

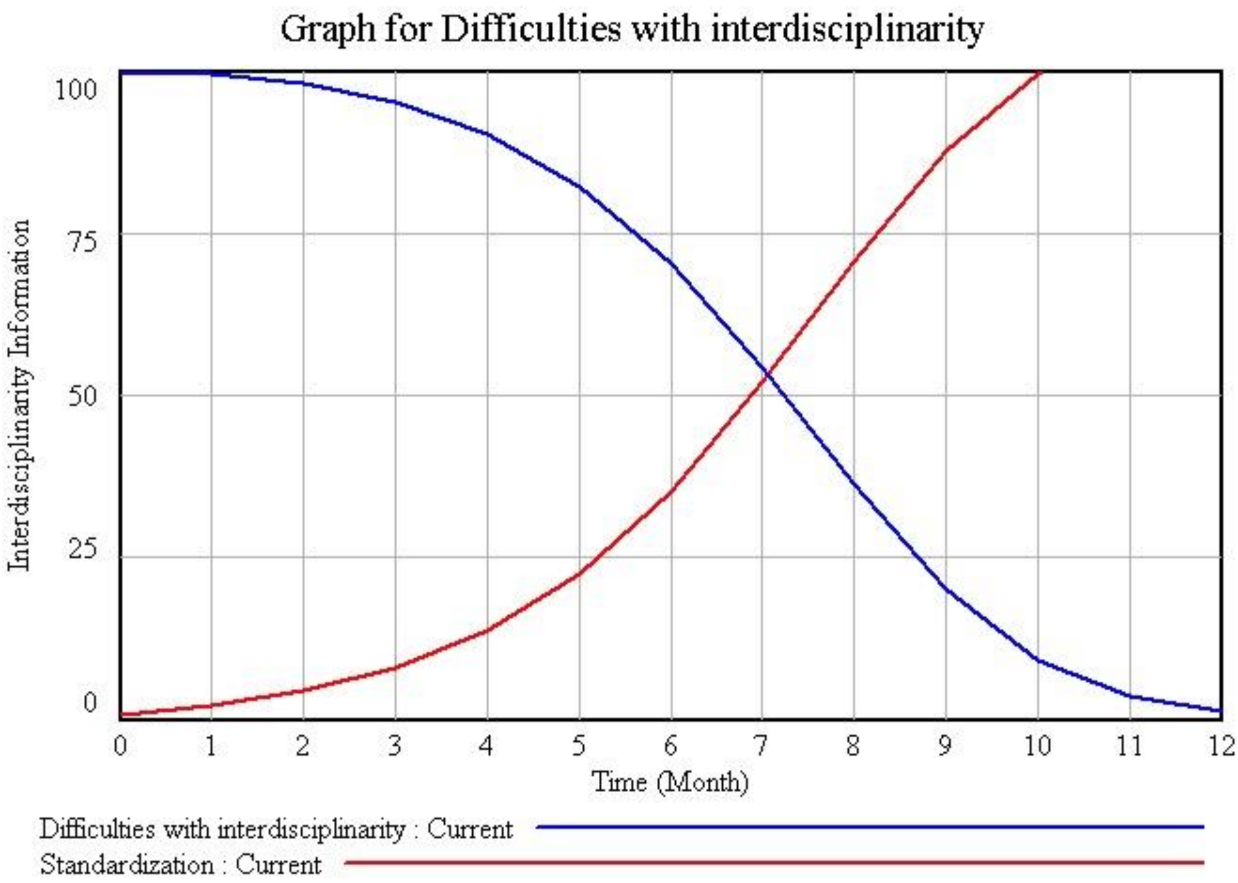
Also, standardization was achieved through documentation like 'Standardized Operation Procedures (SOPs)' and templates for reproducibility of methods and data analysis sections, tutorials explaining basic concepts. Finally, access to information and facilitation of communication through online tools, between collaborators was found to be important (Table 1).

Participants ratings on each node of the preliminary model and techniques applied to improve trading zones provided numerical input to simulate our trading zones model through time. Figure 3 depicts the average behavior of a series of simulation scenarios. Simulation results show a hypothetical research group with an initial difficulty to interpret interdisciplinary data (T0 - blue line) and limited standardization (T0 - red line). In a 12 month timespan, with our standardization training program, after 6 or 7 months, one would be able to perceive a shift between the amount of difficult to interpret interdisciplinary data (T6-7 - blue line) and standardization (T6-7 - red line). Therefore, approximately 5 months of training would elicit changes within our trading zones training model.

DISCUSSION

To our knowledge, this is the first paper investigating the universal challenge of interdisciplinary communication between physicians and statisticians. Our study revealed two primary themes characterizing interactions between physicians and statisticians: the exchange of language and of instruments. These two forms of exchange compose the trading zone, an "arena in which radically different activities could be locally, but not globally, coordinated" by specialists with diverse perspectives and expertise [20].

Figure 3- Diffusion Model Results



Unlike prior interdisciplinary studies that focus on transcending disciplines, the language exchange we observed was rooted in very specific exchange settings where field specific terms and concepts are used to describe specific scenarios and present solutions. In general, physicians and statisticians were unaware that others may not understand these terms and concepts unless they were pressed to explain further. In these cases, they make an effort to translate. In the process of translating, they begin to share very basic/shallow concepts needed to achieve basic communication. For example, when a statistician explains randomization as "flipping a coin," over time and with repeated interactions, this simple language gains more depth and begins to share assumptions about term definitions and concepts [20]. However, we observed this simple language never developed further. This may be due to the transient nature of the interactions we observed, isolated communication rather than consistent ongoing encounters associated with longer-term collaborations. But it may also be due to the fact that translating is inherently difficult and requires time and effort that is rarely available in the day-to-day work-life of physicians and statisticians.

Another key component of the trading zone which emerged as a theme in our study was an instrument exchange in which physicians and statisticians were not simply trading terms, but also instruments to convey meaning, to choose a particular method, or arrive at conclusions. Instrument usage and interpretation involves a tremendous amount of tacit knowledge that is developed through experiential learning rather than written instructions. This tacit knowledge, accumulated over time and through experience, is highly "personal" in that it is not easily "verbalized" and shared through language [21]. As in the case of the language exchange, professionals often don't realize during the instrument exchange that others don't share the knowledge needed to understand and interpret instruments. However, when instruments are successfully exchanged, they facilitate the spread of this knowledge.

Our findings suggested that trading zones among these two professionals are fractionated, but at the same time are collaborative. Through interaction, they don't develop new cultural tools, first because they have already developed their own field languages, tools and instruments, and second because physicians and statisticians gather fractions of their already conceived and learned culture and add fractions of culture from others professional interchanging seeking the agreement and understanding on both sides, trying to figure out their overlap and differences [1].

Study limitations

Although this is an in-depth analysis of the patterns of exchange between clinicians and statisticians, this study is based on a limited number of interviews and its external validity is therefore limited. Also, as we pointed out in previous sections, the relationship we describe could be unique to the clinician-statistician interaction and therefore our results might not be extrapolated to other trading zones. Our sample did not develop a new mixed language and therefore we cannot make assertions about factors that either contribute or detract from the creation of a new one. However, given the difficulty in reaching the stage of a common language, it is not unreasonable to think that the lack of platforms to streamline the process of creation of a standardization might make trading zones less viable.

CONCLUSIONS

Our results may have important implications for future efforts to establish interdisciplinary teams involving physicians and statisticians in research and education. First, it is important that physicians be aware of the reasoning-models; knowing the general principles for collaborators' reasoning should increase awareness about expectations. The same principle applies to increasing awareness about non-universal terms and concepts.

Understanding the different reasoning processes of clinicians and researchers is an important first step in understanding how to improve training for healthcare practioner-researchers and ensure interdisciplinary teams operate effectively. But there is not just one best way of organizing inter-disciplinary collaboration, and even with collaboration, there are different relationships among different professionals that will develop different kinds of trades.

Rather than using generic terms such as interdisciplinary collaboration, efforts looking at the exchange among specialists from different fields should focus on the specific patterns of language and instrument exchange. Based on these specific trading patterns, platforms mixing the optimal use of language and instrument exchange should be devised so that future attempts to establish trading zones can be streamlined.

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Dr. Yen graduated Medical School in the University of São Paulo, at the year 2001. Since then, she completed the IOTHC FMUSP residency program in Orthopedic and Traumatology in 2005, and in 2006 graduated the foot and ankle fellowship of the IOTHC FMUSP foot and ankle surgery department. From the years 2011 to 2012 she engaged a research fellowship in the RoR group at Duke University. Therefore today she is active in the clinical, surgical and research fields, in both academic and private medical practices for several hospitals of the metropolitan area of São Paulo, Brazil.

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Dr. Haglund holds the Endowed Chair as the Distinguished Professor of Neurosurgery with joint appointments in Neurobiology and Global Health at Duke University and currently serves as the key Co-Investigator on one NIH-funded R01 and as the PI on two Duke Graduate Medical Education Innovation Grants and an industry supported Spine Surgery outcome project. Dr. Haglund has been a leading the Duke Global Neurosurgery and Neuroscience Division (DGNN) with a goal to address the surgical need in low and middle income countries. His projects have been developed in Sub-Sharaina Africa.Dr. Michael Haglund has led the Duke University Global Neurosurgery. Dr. Haglund serve as the Co-Directors of the East African Neurosurgery Training Program, one of Sub-Saharan Africa's only neurosurgery residency program housed at Mulago National Referral and Teaching Hospital,

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Dr. Staton's is an Assistant Professor of Surgery and Global Health who practices clinically as an Emergency Medicine Physician. Her research is focused on the trauma and injury care as well as health disparities amount injury patients. Clinically, she has witnessed the burden of injury and the magnitude of its impact on patients, family and communities both in the United States and abroad. In 2011, she completed an ARRA NIH Post-doctoral Fellowship in Mozambique conducting a Preventable Death Project and implementing the Ministry of Health's Clinical Trauma Registry at the country's premier trauma referral center Maputo Central Hospital. After fellowship and post-doctoral studies, she transitioned to Duke and switched focus to addressing injury prevention and care at Kilimanjaro Christian Medical Center in Moshi, Tanzania. Currently, she is funded by a National institute of Health Fogarty Career Development Award focusing at creating a Brief Negotiational Intervention for high risk alcohol use injury patients who presents to the Emergency Department in KCMC, Moshi Tanzania. Similarly, she is conducting quality improvement research focusing on improving quality of care for traumatic brain injury patients who arrive at the KCMC ED.