Situations vs. Standards in Long-Term, Wide-Scale Decision-Making: The Case of the International Classification of Diseases

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This paper presents a case study of the development and evolution of an organizational decision support system (ODSS) over a long period of time and wide geographical area. It uses the design of the International Classification of Diseases (ICD) to address issues of organizational decision making in large, dispersed organizations. Special attention is paid to the tension between standards and local contingency in such systems. Four kinds of "wins" are proposed in this type of decision setting: contingency wins, standardization wins, delegation wins, and translation wins.

The study is based on a longitudinal analysis of the development of the system, currently administered by the World Health Organization (WHO). It looks at a number of strategies the designers of the system have attempted in balancing the need for a "universal" classification scheme with the pluralism entailed by different medical specialties, different national medical cultures, a large, changing bureaucracy, and the evolution of computing.

Introduction

Individuals and groups make decisions in very different ways, involving different use of resources and negotiating processes. Moving up to the level of organizations requires yet another change in resource configuration and negotiations.[1] This is especially the case when discussing large, distributed organizations. Discussions of group decision-making processes have commonly characterized three possible outcomes: truth wins, status wins, and majority wins. This is a description of outcome in relatively small group interaction, either face-to-face or electronically mediated. Very large organizations making complex decisions have such groups and processes embedded in them, of course. But we think that there are as well processes *sui generis* to much larger organizations, and which are important for decision making and problem solving. The primary kinds of processes we describe here are those where the organization is attempting simultaneously to impose standard representations, and to represent multiple viewpoints for decision making.

Turoff and Hiltz describe this problem succinctly as it appears at the group level: "A management or professional group cannot maximize consensus and quality in its decision at the same time. It has to choose which goal is more important. Appropriate structures can be provided to promote either egalitarian participation and lots of opinions or strong leadership and a higher probability of reaching complete consensus." [2] Yet in large organizational decision-making processes, one group *cannot* impose strong enough leadership to produce consensus. Standardization may replace "leadership" in the attempt to manage the difficulties imposed by pluralism, and yet no standard or imposed representation can answer to the situated, contingent nature of problem solving at another locale, as we have been learning from the new wave of cognitive science.[3] Elsewhere, we have discussed this as the problem of organizational *due process*.[4] Taking off from the typology of decision-making outcomes described above, we conclude that there are four kinds of processes that are used to resolve problems of the tension between standardization and local situation: *contingency* wins, *standardization* wins,*delegation* wins, and *translation* wins.

We draw our arguments and materials for this analysis primarily from an historical case study of the development of the International Classification of Diseases (ICD). This is a list of causes of death and disease currently administered by the World Health Organization. It is about one hundred years old, and has been revised nearly every ten years since the nineteenth century. The ICD is distributed as a book (or sometimes embedded in medical record-keeping software) to public health offices, hospitals, and bureaux of vital statistics throughout the world. It contains numbers which correspond to causes of death or illness, and algorithms for arriving at those numbers in complex cases involving more than one disease or cause. In a sense, the ICD is the backbone of a sophisticated organizational decision support tool. On the basis of data collected using the ICD system, decisions are made about allocation of medical resources, whether and how to control epidemics or endemic illnesses, and whether there are shifts in population based on infant mortality rates, etc. We were only able to locate a copy of Anne Fagot-Largeault's magisterial discussion of the ICD after this paper was written. She emphasizes causation rather than organization; but is fully aware that the two are complementary.[5]

We understand that this paper is an unusual one in the ODSS/GDSS literature. We are speaking of decision-making and problem-solving tools and processes that span many organizations and take place over very long periods of time. In addition, much of the ICD and tools like it are infrastructural to the kinds of other decisions more commonly covered in the literature. These are deeply buried in statistics, databases, or the records of bureaucracies. We are far from recommending specific design strategies for building support tools for such decisions. Yet we believe that conceptualizing the role of such tools is crucial to tbuilding a broader, more sociological understanding of decision-making itself. We are here responding in part to Sprague's call for general theories of problem solving to inform the DSS/GDSS/ODSS literature. [6] Sainfort, et. all similarly call for attention to problem solving process, saying "it is almost impossible to determine the exac.

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contribution of the DSS to the final outcome, since it is almost impossible to know what the same problem solver in the same situation at the same time would have done without the DSS. [7] In the matter of long term, large scale decisions, such putative control is never really possible -- thus the attention to *process* is even more critical.

Some of the most urgent problems facing large organizations concern the proper relationship between people, technologies and tasks.[8] Those tasks are often highly distributed over time and space. Large-scale software development projects, for example, take place at many locations, and design and safety decisions made by and for groups which never meet face-to-face. We draw here on the fields of sociology of technology and distributed artificial intelligence for useful concepts in understanding organizational decision-making, including the idea of boundary objects and the French Annalist approach to the study of lists and bureaucracies.

The Nature of Lists as Decision-Making Tools

List making has frequently been seen as one of the foundational activities of advanced human society. Goody argues that the first written records are lists (of kings, of equipment). [9] Foucault and Tort have, in their different ways, claimed that the production of lists (of languages, races, the minerals, animals) revolutionized science in the nineteenth century and led directly to modern science. [10] Latour and others have proclaimed that the prime job of the bureaucrat is to compile lists, which can then be shuffled and compared one to another.[11] What these diverse authors have in common is that they have turned their attention away from dazzling end products in the various forms of Hammurabi's code, mythologies, the theory of evolution, the welfare state and so on. They have instead looked at just what work is involved in making these productions possible. In each case, they have dusted off the archives and discovered piles and piles of lowly, dull, mechanical lists.

List-making is foundational as a way of coordinating activity distributed in time and space, and of passing information back and forth across parts of an organization. Consider an apparently simple problem of coordination that children in many cultures solve routinely: the treasure hunt. In this game a list of objects is made, usually by an adult, and teams of children are each given an exact duplicate of the list. The first team to bring back all the items on the list wins. Even a local, improvised list such as this entails all sort of judgment calls: objects should be hard enough to find to challenge the children's' ingenuity, but not impossible; they should match the kids' resources (e.g., no objects requiring use of a car to find). Typically they are things that are odd but not impossibly rare -- a copy of the front page of the New York Times from June 4, 1964; a green high-heeled left shoe. Teams may decide to coordinate their internal work by assigning each person an item, or working in pairs, or moving as a group, and so on.

When lists are used to coordinate important work distributed widely over time and space, and to inform more important decisions than where to look for an old green shoe, a correspondingly complex organizational structure and infrastructure evolves. The judgment calls are still there, but involve multiple actors, both persons and organizations themselves. The decisions about division of labor remain, but now entail bureaucracies as well as local conventions. As all the authors cited above have concluded, large-scale decision making is impossible without lists. These in turn entrain whole series of substantive political and cognitive changes in the classes they inventory.

The ICD is a particularly powerful list that has received little analytic attention from social scientists. We draw several lessons from our case study of the ICD:
- first, there is a *permanent* tension between attempts at universal standardization of lists, and the local circumstances of those using them;
- second, this tension should not, and cannot, be resolved by imposed standardization, because the problem recurses;
- third, rather, from the point of view of coordination,*ad hoc* responses to standardized lists can be mined for their rich information about the heterogeneous knowledge domain, and information technology built which will support those needs, not subvert them;
- fourth, making this sort of list is an example of the creation of the sort of object which must satisfy members of worlds or organizations with conflicting requirements. In its creation, and later in its use, the complex list is a kind of knowledge representation particularly useful for coordinating distributed work, which often contains requirements of this sort. Some, ourselves among them, would argue necessarily conflicting.[12]

The Impact of the ICD

The ICD was one of the tools bound up in the origins of the welfare state: the epidemiologists and government statisticians who conceived it were concerned with large scale public health measures during the times of the cholera epidemics. [13] It has silently (unlike its notorious cousin in psychiatry, the classification system of psychiatric diseases, DSM I-IV) accompanied all major epidemiological work this century.

The resource-allocation power of a classification of disease appears in the debate about Britain's mortality decline in the nineteenth century. [14] Three interest groups have at different times claimed primacy here using different classification readings - and a share of funding and recognition appropriate to their contribution: *medical specialists* who claimed new forms of treatment rid the country of its major scourges (particularly TB); *public health officials* who asserted the value of sanitation in the cities; laissez-faire *economists* who highlighted the general rise in the standard of living in a successful economy unburdened by expensive medical welfare. The modern interpretation of the outcome hinges on a reading of the Tables of Mortality which listed causes of death by region. These show unequivocally that the new forms of treatment developed *after* the decline in mortality, but in step with local public health measures.

In this century, the ICD has played a similar key role in determining the outcome of epidemiological, public health and economic arguments. We will look at the way it has been used by different groups, constituting both a common and a customizable object for these groups. We will look at the tension between the desire to standardize (so as to be able to perform bureaucratic functions such as comparison over time and space, produce algorithms, compute etc) and the drive of each interested party to produce and use its own specific list. We will also examine the tension between attempts to make a universally standard list and the idiosyncrasies and local circumstances of users.

In organizational decision making it is particularly important to understand communication processes, as several authors have recently emphasized.[15] Maruyama calls this "multi-ocularity".[16] We have discussed this phenomenon under the rubric of "boundary object", drawing originally on our studies of science and technology.

The ICD as a Boundary Object

Boundary objects are those which inhabit different social worlds, which are differently used by members of those worlds. Boundary objects are both plastic enough to adapt to local needs and constraints, yet robust enough to maintain a common identity across sites, times, or social worlds. A taxonomy of different kinds of boundary objects was given in [17] and a preliminary discussion of the use of the concept in organizational decision making in [18]. Two of the types of boundary objects we identified were *repositories* and *forms*. Repositories are ordered piles of objects indexed in a standardized fashion, and are particularly good at handling heterogeneous units of analysis. They have the advantage of modularity. Forms are what Latour has called "immutable mobiles" -- they can be sent and returned over distance and time, capturing certain standard information and deleting many local contingencies from the description. They are advantageous for communication across highly dispersed work groups. To develop this analysis further, let us first inventory the different classes of informational conflicts involved with building up and using the list, and examine the types of informational needs and structures involved in each case.

International Conflicts. One of the values of a list like the ICD is that it can be used in trans-national comparisons. This is useful epidemiologically, in that it enables one to trace specific environmental and nutritional factors that might be involved in the occurrence or spread of particular diseases. It also facilitates the tracking of epidemics and the imposition of any necessary quarantine measures.

These advantages can only be fully exploited if the various states agree on the way information is collected and coded. However, a continuing problem has been that different countries have sent their information in more or less promptly. In the 1920s, France and Portugal were notably slack. Further, once the information arrives, it is often of variable quality - countries with large rural populations finding it difficult to give the same sophisticated medical treatment of each case as heavily urbanized, Western countries. [19] At one stage in the USSR, no attempt was made to compute causes of death in places with less than 10,000 inhabitants! [20] Different states also have different bureaucratic structures - for example, in the nineteenth century, statistics were run by a central service in Italy but were broken down by province in France.[21] The regulations for death certificates have made an appreciable difference to the results of the ICD. Thus in Germany in the 1920s there was no separation between the civil statement of the cause of death and the cause of death issued for statistical purposes. In Switzerland, on the other hand, the statistical cause of death was confidential, making it much *easier* for doctors to cite causes that might distress relatives (and upset insurance companies). When Holland switched over to the confidential system in 1927: "There was a considerable increase in Amsterdam of cases of death from syphilis, tabes, dementia paralytics, aneurism, carcinoma, diabetes, diseases of the prostate and suicide, while deaths from benignant tumors and the secondary diseases such as encephalitis, sepsis, peritonitis etc showed a falling-off". [22]

Further, different cultures place differential emphasis on particular causes of death. A recent case of this has been the curious case of Japan's low rate of fatal heart attacks. A traditional reading of the list has suggested that this statistic is due to nutritional or environmental factors peculiar to that country - level of fat in the diet, etc. Recently some epidemiologists have suggested that the 'cause' may well be that heart disease is a very low status cause of death within Japanese culture, suggesting a life of physical labour and a physical breakdown. Accordingly, what we would call heart attacks are often classed as strokes, since an overworked brain is more acceptable. When this is factored in, they suggest, there is no discrepancy in Japan's figures. These national differences are complicated by the facts that some diseases present differently in different countries. AIDS is one such; malaria another. For the latter, E.J. Pampana noted that: "At a first glance, malaria does not appear to have an international character at all; one could almost say that no other disease is so strictly dependent on local conditions. Malaria might, in fact, almost be called a nationalistic disease, because it takes from the country its very characteristics, as does its folklore. These very localistic aspects of malaria epidemiology are the bricks with which the science of malariology is built ." [23]

Different national schools of medicine can also have disagreements about such issues as simultaneous causes of death. One WHO committee noted that there were indeed such differences; and that if there were no agreement by 'reason', then countries would vary according to : "facts of pathology (or) clinical medicine, (or) public health importance". [24] It recommended that the different countries produce a table of contributory causes for comparison. The problem became unwieldy. In the Census Manual of the International List of Causes of Death there were 8300 terms, representing 34 million possible combinations. If even half the terms could be combined, then an assignation of priority in all possible cases would involve 61 volumes of 1000 pages each.[25]

Finally, managing the ICD has been a charged issue in international politics. Originally, it was run by the French Office Internationale d'Hygiène Publique (OIHP); and was seen by the French government as a sign of their natural lead in international politics. Indeed, when the League of Nations started to gain control of the production of the list, one British diplomat noted that: "an influential clique in the French Foreign Office is moving heaven and earth to retain the Office International unaltered". [26] The United States became key actors when they refused to join the League, leaving the OIHP to mediate between the US and the League of Nations. So doing, they tried to gain more control by squeezing out the International Institute of Statistics from their advisory role. The director of that organization complained that: "The new masters of the world are laying down their law, without any consideration for the rights of others and for an international organization that had received universal respect to that time." [27]

Relationships between developed and underdeveloped countries also figure in the design of the ICD. For the former, with state-of-the-art computing capacity, some kinds of artificially intelligent systems could handle data with more flexibility and detail than has previously been possible. However, the resultant list is often not useful for third world members of the WHO, who lack computers capable of implementing the software. Even with computing power, this level of granularity is not always considered necessary for countries where the vast majority of deaths are caused by infant diarrhoea and contaminated water. Until these issues are solved, who cares about the incidence of rarer diseases? The question is not rhetorical - other member nations do care, since they want to be able to trace their own epidemics (flu, AIDS etc) throughout the world so as to get a picture of their etiology and development.

So international co-operation was hampered within each nation by the diversity of ways of recording and reporting causes of death, by local cultures' rating of the prestige of certain diseases, by local medical cultures with respect to medical controversies and by the different national character of some diseases. It was hampered between nations by the issue of who would control epidemiology, and by the differing national medical needs. The public health actors involved before this apparently simple, homogeneous list could even be compiled included government officials, statisticians, anthropologists, medical analysts, epidemiologists and diplomats.

Government: The State vs. the Individual. Another series of actors emerges when we turn to the relationship between the state and the individual. We have already referred to the problem of ensuring the confidentiality of death certificates - a sequence of perforations in a piece of paper enabling vastly more accurate statistics for certain classes of disease.

The classification of death by suicide also comes under this rubric. Early in this century, many doctors complained about the detailed breakdown of this category, which had 'no prophylactic value'. Statisticians responded that the details should be recorded "for their sociological interest and for the police", and that the Justice Department rather than the medical profession should define the sub-categories. When this was done, however, some moral and political distinctions were inscribed directly into the list. Thus: "In the case of collective suicides, you have to count as many suicides as there are people over the age of majority. Minors have to be considered victims of murder". [28] Similarly, death by starvation was said to be a 'crime' if children suffered it; a 'misfortune' if an adult cause of death.[29] Abortion was another similar case. When criminal abortion was defined in an undifferentiated way as homicide (legal abortion had its own category), it was hard to get statistics about the distribution and safety of different procedures. The definition of stillbirth was as well a political and religious decision varying by nation and Christian sect whether a foetus that had never breathed (or had 'tried to breathe at least three times but failed') was to be recorded as a death. If so, it would both contribute to infant mortality statistics and have a soul; if not, the mother would just be recorded in the morbidity tables as suffering a miscarriage. We are *not* arguing here that the list should have been expunged of all moral and political categories. On the contrary, we will later suggest that this is not possible. At this stage, we merely wish to point out a new set of actors enters into the scene around the very thorny question of the relationship between the state and the individual: political interests, religious groups and ethicists.

Conflicting Needs of Doctors, Epidemiologists and Statisticians. The task of filling in the death certificates falls on the doctor. He or she does not necessarily see the value in accurately filling in a complex form - this patient, after all, is dead, and is the time not better spent on the living? Further, some doctors have complained about any degree of government obligation: "the doctors cling to their independence and ... for the vast majority are imposed to any any intervention on the part of the government or of some bureaucrat".[30] When it comes to use of the tables produced with the list as a basis, in general : "practicing specialists want more categories and urban statisticians want less". [31] For the specialists it is of particular interest to know the breakdown of each disease strain, whereas for the urban statistician suggesting public health policy broader categories like nutrition and sanitation are more relevant. This has at times led to a double bind: "So-called administrative statistics have no value in the eyes of practitioners, who as a result are completely uninterested in it; whereas unless these practitioners provide exact data, then the scientific value of administrative statistics has to be called into question". [32]

An example of this tension is to be found in the special tuberculosis sub-committee of the League of Nations trying to develop a new four digit code for use in sanitaria. "Public health workers want to know: Does a person really have tuberculosis, and, if so, is it infectious? The worker in vital statistics wants details concerning tuberculosis and its relationship to population groups. The clinicians' principal interest in classification is is to have a guide which will help him be definitive in diagnosis and treatment of his patients." They noted that it was "exceedingly difficult for a classification to meet all these requirements". Current codes had been rendered more inadequate by the advent of mass X-rays during World War Two, when millions of apparently healthy people were found to have early forms of TB: "for which there were not sufficiently exact designations". [33] Pressures from the different groups spoke to issues at the core of the design of the ICD. Statisticians, for example, wanted the first ICD to have only 200 categories, since a statistical 'table' as used in censuses could only be approximately 200 lines long. For them, lists had to be stable over time and space, for comparability. This led to a choice of a particular kind of list, not specifically tied to causes of death: "This is why diseases must be classed according to their seat and not their nature or their cause. Because the seat [location] is much more easy to determine than the nature". [34] They stressed that the role of the listmakers was not to produce 'philosophy' (which we can read as referring to the divination of essential causes) but a 'truthful' and 'comparable' list. Spanish authorities wanted the list of general diseases to follow public policy, breaking them down as follows: general and sporadic; epidemic; imported; common to people and animals; professional intoxications.[35] Thus, too, one set of statisticians wanted to rearrange the list so that social-biological factors would be grouped first, and later categories would only be used if these could not be filled. Thus 'puerpural state', 'malformations' and 'early infancy' would go to the top; not in order to give them preference: "The point to stress *is simply that in statistics the social-biological viewpoint comes first and the medico-aetiological second, while the anatomic-functional is only third in order of importance."* [36] ' Violent death' should move up the list too, since this would: "settle various doubts ... as to whether consequences due to visible external causes are to be classified here, or, for example, under infectious diseases (a case in point is infectious diseases of wounds)". Further, there should be a subdivision for diseases for which statistics were required under international conventions (e.g. lead poisoning). [37]

This pluralism brings us uncomfortably close to Foucault's famous list. He speaks of an ancient Chinese taxonomy dividing animals into such fanciful-seeming categories as "those that belong to the Emperor, those that are trained, mermaids and fabulous beasts, those that are included in this classification, and those that `resemble flies from a distance'". [38] There is no homogeneity to the ICD. It is not so much a list of causes of death as a series of dynamic compromises between a wide range of players in a number of different dimensions. Or, as one observer noted: "In short, the nomenclature of diseases and of causes of death established for the needs of statistical organization constitutes a sort of contract between the two organizations who are charged with statistical works - that is to say the service who makes the observations and that which produces statistics with the help of these data".[39]

Industrial Actors.. We have already said enough to indicate that a vast range of people from a series of different social worlds had a stake in how the ICD was compiled and used. Three other

groups that we will not look at in detail in this paper are:
- *insurance companies* These groups wanted a breakdown of the ICD statistics in such a way as would be useful for them: "For example, there should be groups corresponding to the age at which direct compulsory sickness insurance begins, and the age at which compulsory old-age insurance starts". [40]
- *industrial firms* Some of the first groups to produce lists of causes of death were from the vast German chemical companies of the late nineteenth century. For them, relevant variables were whether the deceased had touched/not touched certain compounds, had worked inside/outside etc. Again, a different set of variables from those interesting other groups;
- *pharmaceutical companies* The claims that can be made for different drugs is in part a function of the list of diseases. A classic case of this is cited by Law and Bijker: because of religious restrictions, the Spanish pharmacopeia defines what we would describe as birth control pills with a side-effect of causing high blood pressure as a treatment for hypotension with the side-effect of inhibiting birth. [41] Or it can work in another way. One of us had a student who was a representative for a large drug company. Part of her job was interviewing doctors about whether any of their patients had gotten better from one disease while taking one of the company's medications for another. If yes, that disease might potentially be added to the list of indications for the illness. The student said that she was constantly pressured by her supervisors to "broaden her indications."

We will not attempt here to list all the actors involved in compiling and implementing the ICD, but it should be obvious that something has to give; the list cannot be homogeneous, neutral and appeal to all parties. This is typically the case for boundary objects, which inhabit a number of different social worlds simultaneously.

Coordination, Organizational Decision-Making and the ICD

A number of good people have been working on the problems posed by the ICD for many years. What sorts of solutions have they proposed? In this section we inventory a number of approaches. It should be emphasized from the outset that some of these solutions are consciously applied and others have appeared by default, still others became embedded in bureaucratic "decisions."

Distributed Residual Categories. Indeed, our first solution - garbage categories - might seem to be no solution at all, but rather a studied avoidance of the problem. It does, however, offer some interesting insights. By 'garbage categories' we mean that array of categories where things get put that you don't know what to do with - the ubiquitous 'other'. In mid-nineteenth century Paris, more than 10% of causes of death were 'other causes'. [42] In Berlin at the turn of the century, it was hard to get doctors to complete valuable morbidity information; thus one table gave acute bronchitis 1571, chronic bronchitis 225 -- but bronchitis, without any other qualifier, 12 844. [43] There were three general causes for the creation of garbage categories, or "Undefined Diseases": "either because there was not enough information or because the disease was badly characterized or finally because the doctor failed to formulate a complete diagnosis". [44] It would be extremely difficult to envisage a time when there is no need for these categories. Their management has been a constant thread throughout the history of the ICD. A major feature of this management has been their distribution throughout the list. Thus at the time of the first revision of the ICD, the United States representatives suggested getting rid of the categories "Eclampsia (non puerpural)" and "Children's convulsions", since they were ill-defined (pun unavoidable). The committee rejected the suggestion, since it would lead to the attribution of too many: "unknown causes ... and this would discredit the statistics".[45] Or again, the vague term'haemorrhage' was kept, with a view to: "not over-inflating the figures concerning badly defined diseases".[46] This distribution went to the lengths of distinguishing between two types of generalized other, which one representative had suggested conflating - viz categories 35 and 36, 'Other diseases' and 'Unknown or badly defined diseases': "Proposed conclusion: Each of these two rubrics is very important. The latter in particular indicates what is missing from the other figures in their approach to truth". [47] The need to distribute was urgent - Jacques Bertillon estimated that over half the causes of death would be 'other' in Paris in 1900 if all the residual categories were gathered together.[48]

These categories tend to fix the maximum level of granularity. They can signal uncertainty at the level of data collection or interpretation - forcing a more precise designation could give a false impression of positive data. The major disadvantage is that a lazy or rushed doctor will be tempted to overuse 'other.' By their nature, boundary objects are only manageable if there is a zone of ambiguity written into them: in this case, precise definitions would drive a wedge between doctor, statistician and epidemiologist.

Heterogeneous Lists. Throughout the history of the ICD, there has been a great deal of debate about whether it constituted a nomenclature or a classification. The difference is that a nomenclature is merely a list which does not give any indication of cause whereas a classification gives causes. The advantage of a nomenclature is that it can remain more stable over time. For example, a nomenclature based on the 'seat' of the disease can list a series of indications which can then be used at a second degree of analysis to re-diagnose in line with current theory. Systemic diseases - like AIDS or Systemic Lupus Erythematosis - can be tracked this way, even though the category might not have existed at the time of original diagnosis. Classifications are more convenient immediately, but change frequently.

Intuitively it might seem desirable to have a single well-defined governing principle for the ICD. However, as for residual categories (and for the same reason - the array of players involved), the solution that has emerged over time has been rather to find the appropriate level of ambiguity -- to keep the list as heterogeneous as possible for the different actors to find their own concerns represented. This cashes out in the fact that although the list is in appearance homogeneous, there are at least four classificatory principles involved: *topographical*, the seat of the disease, which part of the body it manifests in; *etiological*, the origin of the disease (genetic, viral, bacterial etc.); *operational*, the responses to certain tests; and *ethical/political*. There is no necessary one-to-one correspondence between test results and a given topographical or etiological feature (though in general one or the other is asserted). HTLV vs HIV is a case in point. HTLV was defined in terms of a positive reaction to a test searching for antibodies. When what we call HIV initially produced the same reaction, Gallo classified it as an HTLV - even though the virus had not been isolated. We have given many examples of ethical and political dimensions above. The definitions of stillbirth, abortion, suicide, iatrogenesis and euthanasia, for example, are the outcome of ethical and political decisions.

Parallel Different Lists. Different groups have found that the list just did not serve their purposes, and so they have modified it. This could happen in a country with a different range of medical problems. For example, the first ICD was drawn up partly through a comparison of the *Tables of Mortality* of six European countries. Little room was left for tropical diseases, and African countries produced their own modifications. Again, specialists

might be interested in a finer breakdown than that permitted by the ICD. Or again, different users might find that their exigencies were not met by the current one - for example medical insurance companies have often produced their own version. As with many other attempts to standardize (computer languages come to mind), each time an international standard is laid down - every ten years in our case - there is an immediate efflorescence of modifications. Rather than lose control of this whole process, the ICD committee has chosen to issue rules for how the list is to be modified. This gives them a degree of control at the second level that they have lost at the primary one. The critical advantage of this secondary control is that it gives an algorithm for working back from the modified list to the ICD itself.

Full Complementary Localization. In some instances, it has been suggested that the list itself be ignored and detailed local studies be carried out instead. Thus the Registrar General of England and Wales, responding to the call for an International List of Causes of Morbidity to complement the ICD, recommended: "large sample investigations into particular groups of morbid conditions ..." instead of international classification, which would impose an order which masked the inherent vagueness of diagnosis. [49] He noted that even for notifiable infectious diseases, intra-national (let alone inter-national) comparison is difficult: "In England and Wales, so far, we have found it impossible to make the statistics of notifications of Tuberculosis the basis for any serious study of inter-local differences of incidence. Even notifications of Infectious or Primary Pneumonia have proved of less service in epidemiological forecasting than we had hoped might be the case". He argued that doctors were too diverse a group to unite internationally around a given list: "... Dr Roesle is tacitly assuming that the flagrant non-comparability of existing morbidity statistics is chiefly due to diversity of classification. the cause of the divergence may lie deeper, and may reflect important differences in the points of view of the practitioners themselves." His conclusion was that time spent on classification was wasted. For example, he wrote of breast cancer: "The fact that this disease does not greatly contribute to the *statistical* incidence of morbidity, is an evil not capable of remedy by any international rules of classification - it can only be cured by raising the standard of hygienic education; that of the public at least as much as that of the medical profession".[50]

This solution seems to suggest that no list at all is valuable. It carries to an extreme the ambiguity of our first two lists and the diversity of the third. However, from the point of view of the ICD this denegation in fact serves to strengthen the boundary object: through open recognition of the tension between the local and the universal. The ICD has been continually tested and its limits set. Boundary objects do not claim to represent universal, transcendent truth - they are pragmatic constructions that either do the job required or recognize their own inability to do it.

Convergent Bureaucracy. Not all the work that has made the ICD more applicable has been done internally through modifications to the list. Indeed, one background factor that has had a great impact has been the convergence of international bureaucracy. What we mean by this is that throughout this century in general people have become increasingly used to being counted and classified - and public organizations have become more adept at the necessary procedures. Inhabitants of undeveloped countries are less likely to slip through the net now than fifty years ago. It is much less likely anywhere that it is the village priest who determines the cause of death.

We introduce this factor as a reminder of the historical and contingent nature of universally applicable lists. In a related domain, Alain Desrosières has shown beautifully how census breakdowns of the populations of Germany, France and England have remained closely tied to the history of work, trade unions and government intervention in those countries. [51] We suggest that as the ICD 'naturally' becomes more universally applicable, this is partly the result of the spread of Western values through the application of our own bureaucratic techniques. These techniques appear rational and general to us, but when looked at in detail prove highly historically contingent.

The convergence of bureacracy here is an example of what the decision literature would call reciprocal interdependence. Tanniru and Jain , following Thomson, say that reciprocal interdependence is where each organizational unit is recursively dependent on another.[52] They staté that the nature of communication support for this type of dependency is virtually unexplored, and offer a GDSS for such decision scenarios. However, since an *a priori* agreement on meaning for all individuals involved is fundamental to their system (p. 289), their solution is of limited generality for the larger class of problems invoked here, since it defaults to standardization.

Computerization. From the early 1920s with the use of Hollerith cards and Powers machines, the history of the ICD is interwoven with that of computing. The chief advantage computing offers today to the ICD is keeping uncertainty at the level of closure on analysis. Computers, that is, offer many ways of "passing through" a data set. When the list involved a relative handful of categories arrayed along one dimension and permanently inscribed with pen and paper, then a whole series of decisions were forced. Even when maximal flexibility was kept, it was impossible to compare large bodies of data simply because the original wealth of material simply was absent. Thus, for example, the difficulty in tracing AIDS historically -- occasional outbreaks of Kaposi's sarcoma were too rare, and often just disappeared into the statistics in an 'other' category. With more computing capacity, more axes can be added to disease descriptions encoded by computers, and more comparability is possible due to added complexity.

Standardized Forms. The goal of standardizing the ICD is, we have shown, by no means equivalent to rendering it unambiguous. Consider, for example, the following definition of a cause of death produced by a committee seeking to standardize death certificates: "A cause of death is a morbid condition or disease process, abnormality, injury or poisoning leading directly, or indirectly, to death. Symptoms or modes of dying, such as heart failure, asthenia, etc are not considered to be statistical causes of death. [53] The committee proposed a uniform death certificate which included fields such as disease or condition directly leading to death, approximate time between onset and death, antecedent causes,morbid conditions, if any, giving rise to the above, other significant conditions contributing to the death.

It will be clear from all we have written that standard forms are essential for the ICD to work, and secondly that these standard forms cannot be over-precise or the different players will not be able to use them. One attempt at a standard death certificate entailed asking busy doctors to do work they had no interest in doing or often any ability to do. It entailed making choices that were more historically contingent than the ICD itself, which allowed a deal of flexibility by not itself making *any* causal claims. *Standardization procedures must be tailored to the degree of granularity that can be realistically achieved.* This issue

is discussed by Fujimura with her concept of "standardized packages." [54]

Conclusion: Coordinating Boundary Objects in Decision-Making

It is unrealistic and counter-productive to try to destroy all uncertainty and ambiguity in boundary objects. By their very nature, boundary objects need appropriate degrees of both in order to work - only in a totally uniform world (within a given speciality) would it be even conceivable to try to impose total precision. This is discussed by Latour and Serres. [55] Rather than root out all instances of ambiguity, decision theorists dealing with standardized lists should instead seek clearly and consistently to define the *degree* of ambiguity appropriate to the object.

No boundary object can be defined once for all. It is the product of negotiation and change. We have noted three spurs for such change. First are changes within one of the social worlds that has a say in the definition of the boundary object. Thus, medical specialists might come up with a new test that causes a reclassification of a number of diseases. Second are changes in the bureaucratic background which increase (or decrease) the applicability of the object -- convergent (or divergent) bureaucracy. Third are technical changes which allow a better match between the actual uncertainty and that "permitted" by the standard case. Computerization provides such an example.

In the above case study, we can identify four types of processes for resolving problems of the tension between standardization and local situation. *Contingency* wins develops as the stringency of standards and constraints on resources collide -- as in the case of "no list", above, or local certifying contingencies. *Standardization* wins where it fits the work conditions across a variety of settings, and where the parts of the organization are in good enough agreement about codes and conventions. *Delegation* wins where the problems cannot be resolved, where there is an overload on local resources, or where it is politically infeasible to accept standardization attempts. Finally, *translation* wins when different actors are able to develop workable boundary objects in the context of stable relationships.

Implications for Designers of Tools for Coordinated Work and Organizational Decision Support Systems

Despite a growing body of evidence from sociology and history of science, distributed artificial intelligence and distributed cognitive science, images of coordinated decison-making in large organizations often involve the attempted imposition of universal standardization schemes. While such standards may emerge in physical systems or certain sorts of market conditions, for the class of phenomena described here no universal standard is possible. The number of actors, the different ways they structure information, the "moving target" nature of collecting scientific information over time when the science itself is changing: all these factors, and more, are true of most important classes of problems presenting themselves in both the "coordination theory" and ODSS areas. It is often difficult to imagine building tools whose purpose is to collect precise, uniform, and complete information from a large domain over a long time -- and invoke the concepts of ambiguity, fuzziness and plastic meanings for their design. The initial designers of the ICD certainly did not intentionally build such features into their data collection system; on the contrary, they were devout positivists, bent on intellectual and moral recruitment to the truth. Yet as the capital "T" Truth remained elusive, they did develop pragmatic workable compromises, many of which used those features. It is premature to specify specific tools at this point in our understanding of highly distributed problem solving and information systems. But some guidelines emerge at this point.

1. In the face of incompatible information or data structures among users or among those specifying the system, attempts to create unitary knowledge categories are futile. Rather, parallel or multiple-representational forms are required. So, for example, instead of trying to represent a disorder of energy diagnosed with acupuncture as a nervous disease in Western medical terms, a parallel representational scheme will avoid imposition of inappropriate categories.
2. Pragmatically, the "Occam's razor" of the coding of information means that too few categories will result in information that is not useful ("alive" or "dead," while having the virtues of simplicity and [near] exhaustiveness, don't tell us much about disease in the world), while too many categories will result in increased bias, or randomness, on the part of those filling out the form. An ICD with 5 million numbers may be more scientifically accurate, but most doctors would not even look at such a death certificate. Thus, at the level of *encoding* tools need to be sensitive to the *working conditions* of those encoding the data.
3. Imposed standards will produce workarounds. Because imposed standards cannot account for every local contingency, users will tailor standardized forms, information systems, schedules, etc. to fit their needs. A good summary of this appeared recently on a feminist button proclaiming, "One size does NOT fit all!" Gasser identified three major classes of informal responses to systems which did not fit local contingencies: *fitting*, *augmenting*, and *working around*. [56] In terms of designing tools for distributed, organizational decision making, a detailed catalogue and analysis of such responses could become part of the designers' toolkit; incorporated in the system, could point out styles of workarounds at the level of coding.
4. Identifying granularity of the problem, then encoding it in the system where appropriate, would complement existing organizational information processing. For example, in natural history work, biologists are often classed as "lumpers" vs. "splitters." Lumpers tend to identify fewer species, lumping together specimens with fine-grain distinctions, and conversely with splitters. Such individual-level habits or tendencies have also been documented among those filling out certificates of death. At this level of individual encoding, it is possible to track decision making and signal bias in one direction or another (and in fact such capacities exist in several domains, both computerized and manual). However, the monitoring of relatively simple habits and creating mnemonic tools to correct for them become impossible at the level of occupational specialties or large governmental bodies. Collective memories and practices have a different structure, and require much more complex representations. Thus, the rule of thumb for designers here would be to tailor the complexity of the representation around this issue of organizational scale.
5. Match the structure of the boundary object information system in the "middle" of the different participants with the mismatch of their information needs. For example, in the case of the ICD, we have a repository maintained by one group of people, "fed" by forms coming in from a widely distributed constituency. There is a good match between the types of information being collected (heterogeneous, non-matching information structures) and the repository; similarly between the use of forms and the far-flung, disparate encoders of information. Another sort of object or system inserted in the middle of this process could be disastrous -- an abstract analytical schema with tightly controlled coding requirements, for example, could severely hamper data collection efforts.

Summary

We have analyzed the case of the ICD as an example of the development of an ODSS over time and space through he use of two boundary objects, the repository and the form. Rather than strict standardization, there was a balance between participants' different needs and capabilities, evolved in concert with a set of organizational practices to support it. There are many suggestive implications for organizational decision making and information systems.

The work in this area has just begun -- with the advent of very large scale information systems and technologies, and increasing concern with collaboration and coordination across highly distributed groups, the issues presented here become pressing. We see our contribution to this set of questions as analyzing the ways human organizations have reached solutions to this class of problems with and without computing technology, and to reflect back in to the technology the angle of vision of history and sociology. On a more practical level, we would like to define as precisely as possible the creation, maintenance, and perhaps destruction of boundary objects in human information processing, especially organizations. This means understanding the structure of the information needs for particular tasks, and examining solutions, failed and successful.

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