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Threats without enemies: the security aspects of HIV/AIDS
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Assessment of intervention actions for HIV/AIDS

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Introduction

The over-arching concept, which forms the basic requirement for the analytical methods, is the relationship between social and political coherence and the experience of pandemic disease. Hence there is a need to address four axiomatic questions asked in all cases: What *has* happened? What *might* happen? What *could*happen? What *should* happen?

The main question, then, for analytical methods is as follows: *What are the appropriate modes of analysis to grip these diverse data and make them tractable for effective policy response?*

The paper [1] presented at the previous Pugwash meeting discussed several analytical methods and so now we return to the axiomatic questions, introducing "effects-based" analysis methods to assess potential outcomes of intervention actions.

Mapping-out the situation space

Firstly, the on-going "situation" must be characterised for the purposes of bounding the primary system dynamics and in order to define the dimensions of the situation-space so that effects of interventions can be formally modelled in terms of situation attributes. Typically the set of situation attributes will include:

- Number of HIV positive individuals
- HIV incidence rate
- HIV prevalence rate
- Number of orphaned children
- Number of AZT babies born per annum
- Number of HIV positive babies born per annum
- Number of AIDS-related deaths

The situation attributes must be amenable to quantification (albeit in most cases the quantities will be estimates scaled from sampled data with wide confidence limits) so that they can then be used as inputs to secondary dynamic simulations to calculate knock-on effects or impacts.

As well as being quantified, situation attributes must also be qualified. The qualification is highly subjective and consists of two stages: cost evaluation followed by acceptability assessment. So, firstly, the range of values for each situation attribute has to be costed. These costs must then be assessed from the perspectives of every one of the social groups that will be affected by any changes to the situation attributes. The assessment effectively sets thresholds of acceptability (i.e. being OK or not-OK depending on who you are.)

This multi-dimensional (across the set of situation attributes) cost evaluation and its associated multi-faceted (across the set of social groups) OK/not-OK assessment (that has been made in terms of the situation attributes) can now be overlaid across the situation-space to give a "cost landscape".

Cross-sections of the landscape appear as iso-cost contours and their associated acceptability thresholds demarcate regions of the situation space as “no-go” regions (i.e. not-OK from all perspectives). Any regions that appear to be universally low cost can then be annotated as potential positions of desired end-states.

The analysis can be based on benefits or utility rather than being based on cost [Mathieson]. Then the desired end-states would be hill-tops rather than valleys.

Figure 1 shows what an iso-cost “map” of the landscape could look like for two of the situation attributes for one social group.

In order to visualise the situation in more than two dimensions we can use a radial plot. Each situation attribute is represented as a radial line on which the current estimate of its value is plotted and coloured according to the acceptability of its cost. There has to be one radial plot for each of the social groups. Figure 2} shows an example of such a radial plot.

Main points for discussion regarding the situation attributes and their dynamics

HIV transmission
This should be split into vertical (mother to child transmission MTCT) and horizontal (heterosexual and homosexual) transmission and transmission through non-sexual incidents (medical and IVDU) so that intervention actions can be specifically targetted.

HIV incidence
It is essential that the probability of false positives in HIV testing is addressed. The ELISA and Western Blot (WB) tests check antibody levels (proteins such as p41, p120 and p160) and, where other diseases are present in the individual, can give false positive results due to their high sensitivity and low specificity. There are other tests for recombinant proteins (such as pENV-9) that are used for blood screening due to their low rate of false negatives.

Question: Is any viral load monitoring done in South Africa? Is there wide spread follow-up of HIV +ve test results with specific antigen tests?

Move away from the edge
Any new ways of measuring the situation attributes that move the situation away from the critical “edge” on which it sits now and that also reduce uncertainty will allow time for less reactive changes to be made, such as preparing the ground for local organisations and women’s groups. It will allow time for nutritional programmes to take effect that will lead right back into lower HIV incidence: “nutritional and antioxidant deficiencies are a requisite prior to reacting +ve to HIV tests and for progression to AIDS”. [R Guliano]

If we can achieve rationality, there will be an equilibrium point at which everyone will be actually better off than they are now.

Figure 1: schematic iso-cost curves against two of the situation attributes

Figure 2: radial plot of a selection of the assessed situation attributes

ANNEX: Understanding the control space

Under what circumstances does continuous change result in discontinuous effect?
“The reader may very well pause at this point and ask what on earth we are talking about. How could a graph possibly be like an overhanging cliff? And why bother about three-dimensional graphs anyway?”
-- E.C. Zeeman.

Three-dimensional cusp models [3,4,5,6] can be used to understand the control space provided that

the system has what is known as a ‘gradient dynamic’ - that is, we are always trying to minimise some function such as cost or loss, and that there are two variables controlling this gradient. A vital element of a cusp Catastrophe model is that it shows there is a range of values of the control parameters, where small continuous increases or decreases in them can result in large fluctuations in behaviour. For example, we could define the two control parameters as follows:

- Control parameter a: system stress (level of uncertainty and trust in the situation attributes plus number of conflicting cost assessments and conflicts of interest)
- Control parameter b: need for intervention action (criticality depends on mis-match between perceived current situation and desired situation).

Put simply the two control parameters represent, respectively, the system’s unpredictability/complexity and the magnitude of the “stakes” if intervention actions fail (or if no action is taken).

The dynamic stimulus is the perceived current situation which is passed through the control function (given the two control inputs) and the outcome is the action/no action response. The surface of the cusp is the entire set of minimum expected cost points for all potential states of the control-space (i.e. values of the two control parameters).

Suppose we have a system, which is evolving and changing with time. If the system has a number N of attributes that describe the changing situation we can think of these as constituting a point in N dimensional space at any one time. Starting at any point in this space, the effect of following a set of changes to the system is to trace out a path through this space. Any particular set of paths will correspond to a particular way in which the system develops over time. The general way in which these paths evolve represents the qualitative dynamics of the system - for example, all the paths might lead to a single point, which we can think of like a hollow or basin. In fact the technical term for this is a basin of attraction. Descriptively, the space itself can be pictured as consisting of a number of ‘attractors’ which we can think of as valleys separated by ridges. The ridges correspond to the critical turning points or Catastrophe Points.

To understand the dynamics of moving along intervention action routes through the cost landscape, imagine that there is a skier skiing down a hillside in the cost landscape (i.e. trying to follow a path that is aiming to minimize overall costs, at least locally.)

The minimising dynamic can be thought of as consisting of slow and fast dynamics. If we start halfway up the side of one of the valleys, the fast dynamic drives us down the hillside to the bottom of the valley. The slow dynamic then takes us along the bottom of the valley. We might then come to a point where this splits into two valleys - a ‘bifurcation point’. The slow dynamic continues to pull us down one of these valleys. This may then flatten out and tilt so that the fast dynamic pulls us smartly down into the other valley. At this point we have crossed a ridgeline - a point of Catastrophe.

So returning to this cusp catastrophe surface of minimum expected cost points, how do the control parameters affect what intervention actions can take place?

If there is national accord regarding tolerance for HIV prevalence and HIV incidence is low (as in Cuba for example) then we are at the back of the surface towards the left corner. As HIV incidence increases there will be a gradual movement up a continuous hill in the cost landscape. This will be rationally and wholly assessed as unacceptable such that any measures taken to control and prevent HIV prevalence can be implemented and there is national will to adhere to the control measures. Hence HIV prevalence would then return to negligible levels settling back into a minimum cost hollow in the landscape.

If, as in South Africa, there are many parties with diverse and often conflicting views added to which there is also a varied range of beliefs about the actual values of the situation attributes, then we are at the front of the surface. The actual values of HIV prevalence will be increasing naturally

with time and only when the value and its implications are acknowledged by all will it be possible to act (this is equivalent to a sudden removal of a wall or a perceptual block). At this point the nation is peering over a cliff edge and the only route is down a very rocky and jagged mountainside.

Is there any way that such a catastrophic jump can be avoided? Yes by reducing HIV prevalence figures at the same time as providing widespread education and care about each other's basic needs. This zig-zag path through control-space moves us perilously along the edge of the cliff towards the back of the surface.

Mention referendums and the voting principle once across the line of acceptance.

Reference [7]} is the inspiration for this short guide to the mathematics of Catastrophe.

References

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