Applying Game Theory to One Health: Modelling Veterinary Healthcare Delivery

Whether human or animal health, the quality of healthcare, drug innovation, treatment decisions and even approval of drugs all depend on sequential interactions and simple economic decisions. The small number of groups which control the outcome is remarkable given the complexity of healthcare systems. Simple game theory can be used to predict the most likely outcomes of drug development, approval and delivery. This article, focused on veterinary healthcare delivery, is part of a two-part series examining human and veterinary healthcare delivery to illustrate how each decision after we seek medical attention is part of a predictable sequence, the totality of which describe a healthcare system. The interplay between the patient, clinician, pharmaceutical company, government or medical insurances paying bills, and regulators controlling access to the healthcare market is therefore predictable and open to influence. Each of the participants in healthcare differ in the way it attempts to maximise its own utility from healthcare: the only commonality to all participants is the value of each sequential transaction.

Success or failure of an investment to develop a new veterinary product is ultimately dependent upon the perception of the safety and efficacy by the regulator, veterinary clinician and animal owner. The most costly and time-expensive phase of product development is pre-registration clinical efficacy testing. This paper examines the decision sequence of the veterinary healthcare system, using modelling approaches to better understand the interplay between the patient/client/clinician team making the decision whether or not to choose a product, and the pharmaceutical company and government regulator who determine which products are made available to the market. All participants influence the adoption / use of products, but differ in the relative level of influence. It is useful to understand how the adoption of therapeutic products can be influenced both for development and product registration purposes, as well as to ensure ultimate financial return in the marketplace.

Fundamentally, there are only five or six types of participant active in any healthcare process which, given the complexity of both animal and human healthcare systems, is remarkable of itself. Each of these perceives the value of a pharmaceutical product differently:

i. **Patients,** or in veterinary medicine, owners on behalf of patients, primarily *value the effectiveness* of treatment quantifies via the extent of alleviation of a medical condition. A constraint is the cost of treatment and their ability to afford it. The extent that the cost of treatment influences decisions about the patient varies with the economic environment within which the owner/patient exist and the strength of the human-animal bond.

ii. **Payers** are *primarily concerned with controlling the costs* of providing treatment (e.g. the owner, insurance company, charity etc).

iii. **Influencers** tend to value effectiveness above cost and have a strong *influence often via prescriptive control over the choice of treatment* (e.g. the veterinarian, nurse, para-veterinary professional).

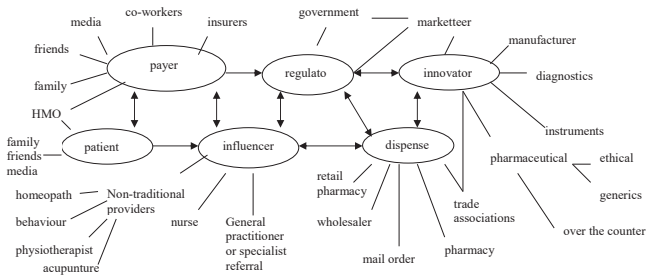
iv. **Innovators** consider the ultimate determinant of *value profit* returned on the time and money invested. Theoretically, this should reflect fulfilment of a market need (e.g. the pharmaceutical industry, researcher).

v. **The regulator** (usually a part of central government) considers the *overall societal value* on the cost of treatment, and is primarily charged with protecting the safety of society and the patient population (e.g. national registration authority).

vi. **Dispenser** is a retail business *maximising profit*. E.g. pharmacy, petstore, wholesaler, mail order, supermarket, herbalist.

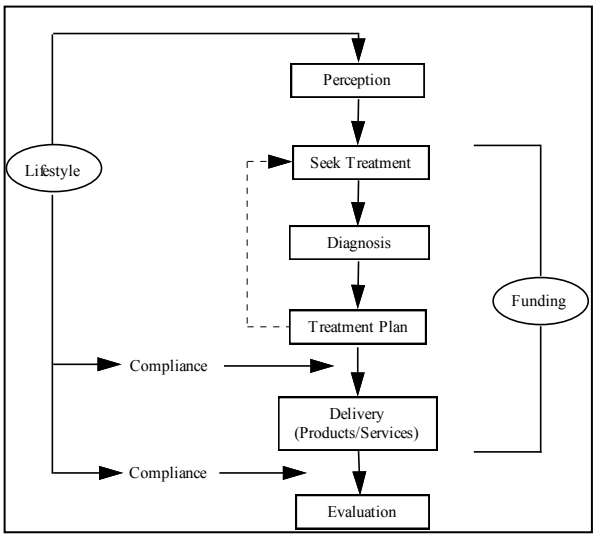
Participants can be grouped into clusters each with sub-levels, all influenced by each other (Figure 1).

Figure 1: Clusters of influence upon each participant in the healthcare process



The core activity around which all participants interact is the decision of the owner to seek treatment for either a real or perceived illness, or to promote health. Without this action, nothing else would occur. Even proactive screening depends on the owner, once informed, seeking treatment, although this also illustrates the power of information in initiating the treatment decision. The process can be broken down into several component parts (see Figure 2) and is universal, occurring in all markets. However, the way the participants interact may differ across markets according to culture, infrastructure and other local factors. There are two supporting decisions. Those decisions regarding the cost of treatment and those influenced by lifestyle/ethical and ethnic factors which affect compliance with treatment regimens.

Figure 2. The healthcare process



The perception of a health-related 'need' is the starting point in this model. The owner observing the patient is the primary decision-maker at this point, but others in the patient-payer clusters are significant influencers, such as family friends and co-workers. The owner perceives a problem exists due to: signs of pain or discomfort; other visual signs; change in function; decreases in productivity; suggestion, such as through mass media; or increased awareness due to education (from clinician, internet, reading, advertising, etc.)

Table 1 illustrates four ranked categories, in order of ease of market penetration for a new pharmaceutical product, such that if market opportunities were being selectively targeted, this reflects the ease of market entry for a product at this level of the healthcare transaction.

Table 1: Two way table illustrating a ease of market penetration when using a targeted innovation strategy based upon perception of illness by the patient

		Ease of recognition of signs of disease by the patient	
		High	Low
Ease of raising patient awareness to signs of disease	High	1	2
	Low	3	4

Category 1 represents conditions that are easily recognised by owners and for which it is easy to raise awareness of the disease. An example could be ectoparasite infestation, where owners are highly likely to detect parasites and may therefore come forward for treatment. For conditions in this category, an owner-targeted educational campaign is likely to be successful at developing the commercial market for treatment.

Category 2 represents the situation where it is easy to communicate the importance of the condition but owners may not be able to easily detect the condition. If awareness is raised sufficiently, patients are likely to be presented if owners suspect the condition. Examples could be endo-parasite burden or sub-clinical mastitis. Thus an owner- and clinician-oriented screening campaign may be more applicable than solely targeting the owner.

Category 3 represents conditions where it is difficult to effectively communicate the forms that the disease may manifest, such as endocrine problems or nutritional deficits which can present in many forms. Raising clinician awareness and provision of diagnostic backup/screening may prove more effective tactics in ensuring uptake of treatment.

Category 4 represents diseases where it is difficult to raise awareness and owners may also not detect signs in the early (more treatable) phases of the disease. An example may be leukaemia, where there may not be any early signs evident. Raising clinician awareness through specialist education and introducing proactive screening may be the only ways of increasing case presentation in this much more difficult sector.

From the point of view of a market-focused innovation strategy, categories 1 and 2 can be influenced much more easily than 3 and 4, so it is less easy to enter or to expand the market. Category 3 patients are likely to be brought forward at various stages of disease but it would be more difficult to target preventive measures at diseases in categories 3 and 4.

Once the owner recognises a problem, the decision is whether to seek treatment, then where to seek it. The factors influencing the owner to seek treatment include: perceived potential severity of illness – death, disability; cost; accessibility; the belief that something can be done. Once the decision to proceed with veterinary care has been made, the decision-maker becomes the payer. Where the payer is the owner, the owner can maintain decision-making power. The decision at this level is influenced by cost, access and belief that a certain type of provider can help. Where the payer is another body, e.g. corporation or insurance, it influences the decision through "payment rules" which can restrict access to some providers / types of providers and aim to contain treatment costs. The payer's decisions are influenced by considerations of their own total cost and perceived treatment quality and final economic outcome.

Socio-economic status for individuals and current market conditions (e.g. feed and meat prices) also come into the debate when trying to distinguish whether to choose high cost – high quality treatment (prioritised as category 2) or low cost - low quality of treatment (prioritised as category 2). Although it is felt that in serious conditions or where there is either a very strong owner-animal bond or economic imperative (e.g. equine stud medicine), it is likely that the balance of opinion will favour high-quality treatment, in less urgent or less severe conditions, alternatives may be sought (e.g. pharmacy advice or self-medication) and the trade-off may be consciously made to seek lower cost and lower perceived quality (and possibly efficacy) of treatment (Table 2) or avoid treatment cost totally by making the decision to cull livestock.

Table 2 illustrates the ease of market penetration when using a targeted innovation strategy based upon the cost of a healthcare visit versus the perceived quality of the treatment.

Table 2: Two way table illustrating preference of treatment quality based upon the cost of a healthcare visit

		Cost of visiting provider	
		High	Low
Perceived quality of treatment	High	2 or 3	1
	Low	4	2 or 3

Clinical evaluation of the perceived problem results in a diagnosis, which is a decision as to what constitutes the specific problem. The primary decision-maker when the owner has selected to seek treatment within the medical provider network is either a veterinarian or a pharmacist / agricultural merchant. The latter plays a more major role in markets where owners can more readily treat, or in other markets where a problem is not perceived as severe and OTC (over the counter) products are available to treat. The factors influencing the veterinarian's diagnosis are: experience, continuing professional development courses, the manufacturers, professional bodies, the payer and the general media, whilst the client's 'diagnosis' can be a function of personal experience, education, word of mouth, or media influence.

Once the problem has been 'diagnosed', a treatment plan is established to deal with the problem. The treatment plan, in some cases, creates a loop back to the 'seek treatment' decision (Figure 2). The treatment plan of a veterinary provider may include a referral to another professional. The treatment plan for the veterinarian can include one or a combination of: pharmaceutical intervention (both prescription or non-prescription); nutritional changes; behavioural modification; surgery, or referral to another provider. The owner influences the provider by providing information concerning personal wishes or the likelihood of compliance with a certain plan. The veterinary provider's treatment plan decision is derived with a focus on efficacy, safety and cost. The payer exerts influence on the veterinary provider and may limit the use of certain treatment interventions, or demand a specific sequencing of treatment interventions. The payer's value relies on a balance between cost and efficacy. If the payer is an insurer or commercial producer, typically they aim to limit overall costs with a herd / client population perspective (as opposed to a case-by-case perspective). The regulator's decisions focus on the wider population, not for an individual. These decisions are a function of the perceived benefits of allowing a product to become available balanced against the 'risk' of adverse outcomes that regulator is willing to embrace on behalf of society. At its most simplistic level, the regulator can either take the risk that a valuable, safe treatment is kept off the market, or they can take the risk that an unsafe treatment is placed on the market (i.e. a type 1 or type 2 statistical error).

When a pharmaceutical product is part of the treatment plan, there are three choices to be made:

a. which class of drugs is appropriate for the plan?
b. which specific molecule is appropriate?
c. which brand in a "generic" environment (based on cost/ brand recognition)?

Which product the provider will choose and the ease with which new products will be able to penetrate the market, is determined by the efficacy of the treatment, the cost of the treatment and the ease of distinguishing the product from other products with the same or similar indications of use. This is where a pharmaco-economic approach is adopted in practice. Tables 3 and 4 illustrate the way product development strategies can target different types of market to maximise the penetration of a new product.

Table 3 illustrates the ease of market penetration when using a targeted innovation strategy based upon criteria of treatment cost and efficacy.

Table 3: Two way table illustrating a ease of market penetration (1 = easy, 4 = very difficult) based upon criteria of treatment cost and efficacy

		Efficacy of treatment	
		High	Low
cost of treatment	High	2	4
	Low	1	3

The ideal product for the owner/patient would be a highly efficacious, low-cost treatment (category 1), however, highly efficacious products are generally premium-priced (category 2). A high-cost, low-efficacy product would not be well received by the market, given accurate information.

If distinction cannot be made based on cost as in Table 3, branding strategy and advertising will play an increasingly important role in distinguishing one product from another (Table 4).

Table 4: Two way table illustrating a ease of market penetration based upon branding and treatment cost

		Cost of treatment versus rival product	
		High	Low
ease of distinguishing product from rivals	High	3	1
	Low	4	2

1 = Easily distinguishable option with few or no rival products and preferential pricing or superior efficacy.
2 = Where there are many generic rival products of equivalent efficacy, the product needs to represent an easily discernible option or cost less.
3 = Where there is little direct competition, but many alternatives, clear product distinction will have to outweigh relative costs.
4 = In a high competition market, with many alternatives and pricing is not favourable, this represents a very difficult market environment in which innovative focus has to be upon production and manufacturing processes to decrease cost of production.

Thus, in order to influence the level of demand for a new product, some basic criteria need to be fulfilled:

1. Easily distinguishable option with few or no rival products and preferential pricing or superior efficacy.
2. Where there are many generic rival products of equivalent efficacy, the product needs to represent an easily discernible option or cost less.
3. Where there is little direct competition, but many alternatives, clear product distinction will have to outweigh relative costs.
4. In a high competition market, with many alternatives and pricing unfavourable, this represents a very difficult market environment in which innovative focus has to be upon production and manufacturing processes to decrease cost of production.

Besides the efficacy of the product, the owner's decision to comply with the treatment plan is an important determinant in the effectiveness of the treatment plan, and it is important that the plan is agreed in advance to maximise the chances of successful implementation.

From the perspective of the pharmaceutical innovator, if an array of product candidates are available, the sequential targeting to meet the needs of the patient / owner, provider, and payer in the sequence of the treatment plan can identify which product candidates are likely to meet with the highest success rate. The over-arching task is balancing the ease or cost of development against the anticipated market value and to perform a cost:benefit analysis and profitability analysis to determine whether the project justifies the diversion of resources away from other opportunities.

Keeping a balanced portfolio can be an important part of managing the risk of product development. Where several leads are generated from the same platform of expertise and only a couple can be pursued, the implication is that the opportunity-cost might be as large for the candidate which is not chosen for development as for the lead candidate. Table 5 illustrates the type of prioritisation process required when balancing research and development costs against potential market value.

Table 5: Two way table illustrating the overriding aim of research and development activities

		Market value	
		High	Low
Cost of development (measured in time and finance required)	High	2	4
	Low	1	2

There is a trade-off when balancing high cost and high market value against low cost and low market value (both prioritised as category 2). This decision will be partly based upon the cost:benefit ratio of each, the opportunity cost and risk management in terms of probabilised success, portfolio management and overall potential earnings of the project given similar profitability.

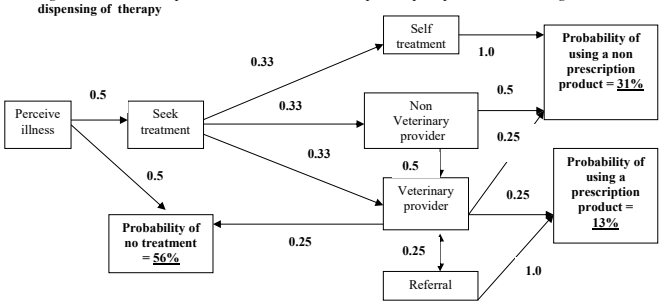
The delivery of a service or a product is prescribed in the treatment plan. The delivery of a pharmaceutical product to a patient according to a treatment plan, includes three things: the drug, a delivery mechanism, and information about the drug. The primary participant at this stage is the dispenser. The dispenser can be a retail dispenser – which includes a stand-alone pharmacy or a pharmacy as part of another retail business (grocery, department store, etc.), a veterinary clinic, a university faculty, or mail order. The influence the dispenser has is a function of which type of dispenser they are and the local regulations governing their activity:

a. Retail dispensers generally have no decision-making authority. They can influence the owner when the product is multi-sourced and will inform the patient about cost or plan options when relevant.
b. The veterinary clinician as a dispenser has decision-making ability may be constrained by the payer through reimbursement rules/cost.
c. Mail order / online dispensers have influence similar to that of retail dispenser.

The influence on drug delivery decisions is primarily a function of the dispenser's profitability. In other words, if a dispenser has the freedom to influence a patient, how they choose to influence a patient is driven by what is most profitable for the dispenser. The dispenser may also be influenced by trying to limit the owner's cost to preserve a long-term relationship. The delivery decisions that are influenced by the dispenser are primarily decided on by the payer and the owner. The regulator has decision-making authority over the types of pharmaceutical dispensers that exist in a given market.

A key determinant of success for the pharmaceutical company is to work out how to influence each of the decisions in the transaction. Figure 3 is a worked example, where the probability of each set of decision choices has been set at equal (e.g. 50% chance of choosing to treat versus not treat, or a 33% chance of choosing between the three possible providers of treatment, etc). The exact trend can be established by local market research and each of these sets of decisions can be adapted according to concurrent trends (which would change over time even in the same market). Through education or awareness campaigns, for example, it can be made more likely that once a condition is detected, treatment will be sought. This decision could realistically be raised to over 90% seeking treatment versus those choosing to ignore the signs. In the case of a flea treatment, however, education campaigns could also be used to influence people not to seek treatment from a veterinary provider and the option, set arbitrarily at 33%, may become only 10%. In doing so, owner medication could be increased to account for the majority of treatments, increasing OTC sales, taking the expense of veterinary consultation out of the system. The types of product most likely to be adopted could therefore be influenced. Using this type of model, the pharmaceutical company can also rationalise which decision steps are most cost-effective to influence and target resources to maximum effect.

Figure 3 : Worked example of a decision cascade from the point of perception of illness through to dispensing of therapy



During the treatment plan and after its completion, there must be evaluation of the plan's effectiveness in solving the health problem identified during diagnosis. The owner

is the primary decision-maker with regard to whether or not a treatment plan has worked, and evaluates efficacy in relation to total cost of treatment plan. Owner's evaluations are based on: cost, symptomatic relief, ability to resume normal activities or demonstrable change in the condition (i.e. efficacy). The veterinary clinician is a co-evaluator when a patient returns. The clinician evaluates a treatment plan based on their visual evaluation, the owner's own evaluation, repeat investigations, and empirically upon whether any better outcome could be hoped for using alternative treatments. The clinician only has the potential to evaluate a plan if the patient returns to the provider after the treatment plan was implemented. So, in many cases the clinician must assume a result.

Discussion

The owner has a great deal of influence over the entire process and typically controls whether or not a healthcare intervention proceeds at all. If the owner does not perceive a problem exists, nothing happens. By the same token, just because an illness does exist and is recognised doesn't mean treatment will be sought. Lack of awareness of solutions, denial, and fear of the consequences are all relevant factors. The more difficult a problem is to perceive, the less likely treatment will be sought. When it comes to deciding *where* to seek treatment, the owner has a variety of choices and can choose to stop and exit the healthcare sequence any time along the way. At the level of the veterinary clinician (a key influencer with substantial numbers of patients waiting to receive treatment), having sufficient time to explain the disease, to share the options for treatment and to internalise the decision into a collaborative disease management effort, in which the owner is fully engaged and therefore more likely to comply with the regimen, is important. It is helpful at this time to discuss the realistic expectation of benefits and side-effects, as well as the consequences of not completing treatment. By virtue of improving compliance with the treatment protocol, the patient is more likely to benefit to the full extent from the treatment and the pharmaceutical company will receive the full revenue.

As researchers and pharmaceutical innovators, we need to adopt a broad view of healthcare. The owner has a very large amount of influence over the transaction as a whole. If a problem is not perceived or treatment is not sought, then no sale will occur and innovation will not be utilised. The owner's decision-making capability or influence is constrained by clinicians and payers, but in different ways for different reasons. The veterinarian's influence over the patient is primarily due to expertise and controlling access to prescription-only treatments. If the owner believes he is not qualified to identify and solve the patient's problem, he/she gives control of this decision to an 'expert'. In those markets where owners are not allowed to treat, they must rely on the veterinarian for access to some treatments (e.g. prescription drugs). The veterinary clinician tends to be the decision-maker at the diagnosis stage, and to be the primary decision-maker at the treatment plan stage (while constrained by the payer). Clinicians can influence patient selection at the perception or seek treatment stage, through screening (e.g. routine blood profiling, parasite flotation, nutritional sampling etc.). It is likely that the level of information provided about treatment options has a large effect at this stage. Table 6 summarises the key decision-makers at each level of the adoption process which influences the progression of the veterinary healthcare transaction.

Table 6. Summary of the decision-makers and influencers at each level of the adoption process.

Participant / Stage	Patient	Veterinary Provider	Payer	Dispenser	Regulator	Innovator/ Manufacturer
Perception	**Primary decision-maker**	Influence through routine screening and information	Influence through paying (or not) for routine screens			Influence through awareness campaigns
Seek Treatment	**Primary decision - maker**	Influence through availability and cost			Influence access and availability	Influence through helplines and educative campaigns
Diagnosis	If treat, then decision - maker	**Primary decision - maker**		Influence in self - treatment situation		Influence by education, provision of diagnostics
Treatment Plan	Influence through opinion and requests	**Primary decision - maker**	Secondary decision - maker, influences through reimbursement rules	Primary/ secondary decision - maker in self - treatment situation	Tertiary decision - maker, controls band of possible treatments	Influence primary decision-maker regarding selection of Rx and its inclusion in treatment plan
Delivery			**Primary decision - maker**	Primary decision - maker. Some delivery decisions	Influence type of dispensers & level of control	
Evaluation	**Primary decision - maker**	Secondary decision - maker if patient returns for evaluation				Influence through helplines and making comparative data available
Compliance	**Primary decision - maker**	Limited control	Influence through ease of payment and level of cover			Influence through education and helplines

The owner or animal keeper may have to allow a payer to exert influence for economic reasons and cede a degree of control to the payer for the payer's role in bearing the patient's costs. The payer, however, does not make decisions on a real-time basis, like the influencer, owner or provider. The payer generally acts on the decision in advance, through a set of economically-driven programme rules.

Summary

- Provision of healthcare is fundamentally a transactional sequence and is the mechanism by which the participants in healthcare interact and rationalise their perspectives of value into a common economic exchange.
- The points of influence and the types of communication that can be used by pharmaceutical companies to influence the uptake of novel technologies have been illustrated. In the healthcare industry, demand generally pre-exists education, awareness and supply of treatments.
- The initiating step in the sequence of healthcare transactions is the individual adoption process of the patient, which includes the perception of illness, the decision to treat, diagnosis, setting up the treatment plan, the delivery of the drug and evaluation of the effectiveness of the treatment plan which impacts compliance. Each of these steps provides a potent point for influence and can be used to influence the adoption of products, and in strategic planning to target market niches where adoption would be most rapid for new products.

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