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Infectious Disease Externalities

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Glossary
Endogeneity An economic variable is said to be endogenous if it is a function of other parameters or variables in a model.
Equity Equity is not necessarily to be identified with equality or egalitarianism, but relates in general to ethical judgments about the fairness of the distribution of such things as income and wealth, cost and benefit, access to health services, exposure to health-threatening hazards, and so on. Although not the same as ‘equality’, for some people, equity frequently involves the equality of something (such as opportunity, health, and access).
Externality An externality is a consequence of an action by one individual or group for others. There may be external costs and external benefits. Some are pecuniary, affecting only the value of other resources (as when a new innovation makes a previously valuable resource obsolete); some are technological, physically affecting other people (communicable disease is a classic example of this type of negative externality); and some are utility effects that impinge on the subjective values of others (as when, e.g., one person feels distress at the sickness of another, or relief at their recovery).
Herd immunity The effective stoppage of the spread of a disease when a particular percentage of a population is vaccinated. This critical percentage varies according to the disease, the interactions between members of the population and the vaccine, but 90% is not uncommon.
Market imperfections Markets in health care are notable for ‘failing’ on a number of grounds, including asymmetry of information between producers (medical professionals of all kinds) and consumers (patients actual and potential); distorted agency relationships, failure of patients to behave in accordance with the axioms of rational choice theory; incomplete markets, especially those for risk; monopoly; and externalities and the presence of public goods.
Public good The technical meaning of a ‘public good’ in economics is a good or service that it is not possible to exclude people from consuming once any is produced. Street lighting and national defense are classic examples. Public goods are nonrival in the sense that providing more for one person does not entail another having any less of it. Some externalities have the character of publicness, such as the comfort one may have when others are protected from ill-health.
Rationality Technically, in economics, rationality means behaviour in conformity with axioms such as: completeness (either A is preferred to B, or B to A or an individual is indifferent between them – where the As and Bs are objects of choice); transitivity (if A is preferred or indifferent to B and B is preferred or indifferent to C, then A is preferred or indifferent to C); continuity (there is an indifference curve such that all points to its north-east are preferred to all points to its south-west); convexity (the marginal rate of substitution is negative); and nonsatiation (more is always preferred).
Utility Variously defined in the history of economics. Two dominant interpretations are hedonistic utility, which equates utility with pleasure, desire-fulfilment, or satisfaction; and preference-based utility, which defines utility as a real-valued function that represents a person’s preference ordering.

Introduction
Infectious diseases are caused by pathogenic microorganisms, such as viruses, bacteria, parasites, or fungi. For almost any infectious human disease, what one person does about it affects the probability that other people get infected. Some infectious diseases spread from person to person through direct physical contact as in the case of sexually transmitted infections. People can also shed an infectious agent into the air, water, onto food, or other surfaces where other people come into contact with it and become infected, as with respiratory or diarrheal infections. Some infectious agents have life cycles that involve stages in both the human host and in a vector organism such as a mosquito. Thus in the case of malaria, an infected mosquito transfers the malaria parasite to an uninfected person through feeding, but an uninfected mosquito can likewise become infected by an infected person, making it possible for the mosquito to infect someone else. Infected people do not always play this role in infecting other people because humans may be dead-end hosts. For example, people infected by roundworms with trichinosis pose no risk to others as long as the larvae in their flesh are not eaten by suitable host animals that are subsequently eaten by other people.

To this point, one person puts another at risk because the first person is infected. Although operative for most infectious diseases, this mechanism is not the only one that affects the risks of infection faced by others. People may put others at risk of infection without being infected themselves. People who do not spray their own houses with insecticide to kill mosquitoes and other disease vector organisms put their neighbors at risk regardless of whether they themselves are or become infected or not.

In all these situations, people face choices. At an abstract level people are making choices about prevention including immunization and about therapy. For any actual disease, these choices are about a wide variety of day-to-day actions.

Of course, epidemiologists and other researchers on human health are well aware how infections spread and, in particular, that the actions of people affect the risks that others face. Epidemiologists use terms such as herd immunity.
Basic Nature of the Externality

Unlike epidemiologists, economists predict behavior and devise policy using the hypothesis of rational decision making by self-interested individuals who pursue objectives subject to constraints. To the extent that people are selfish, they ignore the consequences to others put at risk by their actions or failure to act. It is the discrepancy between the choices made by this type of individual and the choices that are desirable for society as a whole taking into account all the consequences of an individual’s actions that defines the externality and gives precision to this central concept in the economics of infectious disease control.

If individuals do too little of something from society’s perspective, the classic solution to the problem of such an externality is to subsidize the activity – and in the reverse situation to tax the activity. With more than one activity going on simultaneously, it is desirable to think in terms of a package of interventions. For instance, if there is a preventive activity and a therapeutic one, the government should intervene to influence both and it is natural to ask how these interventions should be coordinated. If an infection is transmitted from one person to another, and if a person once infected recovers to be again susceptible, then the optimal package is to subsidize prevention and therapy at equal rates. The externality arises because people spend too much time in the state of being infected and it is socially just as desirable to give them incentives to stay out of this state as to get out of it once they are in it. This finding underlines that both prevention and therapy are associated with externalities. For other diseases from which people do not recover but rather die, or from which they recover to be immune, the package has different qualitative properties. In the case of vectors there may be many different types of prevention in terms of their roles in the model, with consequently different rates of subsidy.

Not all formulations of dynamic models of infectious disease lead to externalities or at least ones that justify government interventions. For instance, consider a simple model in which immunization always confers complete immunity, people if infected stay that way forever and never die, there are no newly born susceptibles, and all individuals have the same preferences (including attitudes toward risk and time) and susceptibility to infection. In this model, everyone gets immunized at the same time. This time is determined by the overall infection rate which determines the risk of infection and therefore the benefit of immunization. Once everyone is immunized, there is no one left to benefit from other people protecting themselves against being infected and therefore, no reason to move the time at which everyone who has remained susceptible gets immunized. Consequently there is no justification for government intervention to offset an externality. But this example is not very general and its importance is in emphasizing that it is being infected, rather than being susceptible and potentially infectable, that generates the externality. In general, even in models for which the only choice is to be immunized or not, there will be a justification for an optimal subsidy to immunization because one or other of the assumptions stated above do not obtain.

There is even the possibility of positive externalities if individuals increase activity that puts them at risk of infection. An example of this result occurs when there is more than one (homogeneous) group in which the groups mix together. First, consider a high-activity (and therefore high-risk) group mixing randomly only with its own members. The infection rate will be high. Now consider a second, low-activity group that increases its level of random contacts from none to one, some of which are with the high-activity group. Any member of the low-activity group who becomes infected does not infect anyone else because they have no more contacts. But by diverting high-activity people from having contact with other high-activity people, the prevalence of infection overall may fall and if the effect is strong enough, the infection may even disappear. The example illustrates not just the possibility of positive externalities but also the danger of thinking in terms of average activity levels without regard for the variability in activity levels in the face of a highly nonlinear process.

Policies to Offset Externalities

The general expectation, however, is that people do too little from a social perspective to avoid being infected, either by making too little effort to avoid becoming infected or to recover once infected. In principle, these problems could be fixed by subsidies, but in practice subsidies may be infeasible so that the first best as seen by society is unattainable. To internalize the externalities associated with infectious diseases optimally, subsidies have to be targeted at outcomes such as the probabilities of becoming infected or recovering from infection. If each probability depended only on inputs that could be subsidized then these inputs could be targeted. But in practice such probabilities depend on many inputs, both marketed goods and services such as insecticides, bed nets, medicines, or the services of health professionals, and non-marketed inputs such as time and effort by the person involved who may also suffer side effects in the case of therapies. All these inputs may be brought together in activities that may be spread over time and space and expensive to monitor, and therefore hard or impossible to subsidize. Some health-related activities are even private and intimate. Consequently, policy may not be able to achieve targeting at the probabilities but rather only at some of the inputs not all of which are necessarily used exclusively to affect the probabilities, hence situations of the second best.

Examples of imperfect targeting abound. For instance, one can subsidize hand soap but not the outcome of sanitized
hands. Soap may be used for other purposes than health-related hand washing such as clothes washing that are then subsidized as well with a loss of economic efficiency. If people find washing hands disagreeable but its social benefits are large enough, it may be necessary in theory to pay them to wash their hands but it may be impossible in practice to do more than give soap away free. Paying people to take soap is not the same thing as getting them to use it to wash their hands. In the case of freely provided bed nets for protection against malaria, it has been claimed that they have been diverted for other uses such as fishing, but a recent review has found almost no such evidence. In the case of sexually transmitted infections, it is safe sex acts that should be subsidized, but typically what has been done is subsidizing or giving away condoms, which is not the same thing as ensuring their use. In the case of tuberculosis, programs of directly observed therapy short course (DOTS) pay for patients to be supervised to make it more likely that they take their medicines. People who do not comply and do not recover continue to infect others, and may even develop drug-resistant infections through incomplete adherence to the therapeutic protocol and then infect other people who in turn are more difficult to cure even if they comply. In principle, people could be paid to maintain their uninfected status as regards human immunodeficiency virus (HIV) or other infectious diseases if it is possible and cheap to test infection status. But it will often be much more difficult to implement subsidies to correct the externalities of infectious diseases than to deal with other types of externality such as vehicular pollution or congestion, which themselves pose difficult enough challenges to the implementation of the first best even under ideal conditions.

A failure of the government to intervene, either completely or partially, has implications for the effect on welfare of changes in the parameters of the system. The outcome can be immiserization, a perverse transformation of a seemingly beneficial change into an actual decrease in welfare. For instance, there is the question of how welfare responds to a lowering in the cost to individuals of being infected because of a more effective treatment. If the externality has been internalized by first-best government interventions, welfare is always increased by such a change even though the infection rate likely rises. But if the externality is not internalized, the direct effect of the reduction in the cost of infection (corresponding to the only effect if the externality were internalized) may be overwhelmed by a worsening of the externality. The reason immiserization may occur is that people make choices about prevention and therapy that are socially suboptimal because they disregard their effect on the welfare of others. A decrease in the private cost of infection could worsen this discrepancy between the socially desirable choices and privately rational choices about prevention and therapy, and on balance welfare declines even though the direct effect of the decrease in the cost of infection is to increase welfare.

Instead of, or in addition to subsidies, governments use methods of coercive physical control such as quarantine of people who may be incubating an infection, isolation of people known to be infected, and culling of domestic animals that may play a role in the infection of people. Thailand has successfully used administrative measures such as tracing clients who attend clinics for sexually transmitted infections back to brothels where condoms are not used and then pressuring brothel owners to ensure that condoms are used under threat of closure. DOTS has aspects of a subsidy and physical control depending on how one interprets the way it promotes compliance with the drug protocol. It does not mandate compliance subject to coercive sanctions but its supervision could either be thought to facilitate compliance by lowering its cost, for instance by providing a reminder, or to raise the cost of not complying by hectoring and nagging. In either case, it influences people one-on-one, rather than through a general subsidy of something people purchase.

People subject to policies of physical restriction are usually not fully compensated for the costs to themselves and so the policies are often resisted and dodged. In the case of isolation, people may have access to therapy so there is that benefit to them which promotes compliance. During the severe acute respiratory syndrome (SARS) epidemic in Taiwan, quarantined people were brought food and had odd jobs done for them to lessen their costs of compliance. In other cases, compensation may help induce compliance although it is important to ensure that it does not result in perverse effects such as the needless slaughter of animals by making such activity profitable.

**Need for Persistent Policies**

In addition to specifying how to target subsidies, program design has to address whether interventions need to be permanent or temporary. If it is optimal for the infection to remain endemic at some level, then subsidies will have to be permanent because there will be an ongoing discrepancy between the socially and privately desirable levels of prevention and therapy. Beginning from an infection rate that is different from the final one, the discrepancy between the social and private incentives to undertake prevention and therapy will be changing over time and consequently so will the optimal levels of subsidies as the infection rate settles toward its long-run endemic level. If, however, the infectious disease can be eradicated, then by definition further subsidies will not be necessary and programs can be ended. Indeed, it is this hope combined with the end to all the costs borne by individuals that makes eradication for all its difficulties such an attractive goal.

In the absence of scientific breakthroughs of an almost magical sort, however, eradication is not likely in the near future for most infectious diseases. One reason it may nonetheless be possible to lessen expenditures over time is if part of the reason for subsidies is to pay for the dissemination of information about the infection and how to respond to it. Information dissemination may be implicit, as when someone learns about the benefits of prevention or therapy by trying them out. Information dissemination may also have an externality component if people learn from others and without compensating the people from whom they learn for their own costs of acquiring and providing this information. There is also an externality associated with information if a lack of information leaves people acting against their own interest in ways that also have costs to others. Once the message is out, however, it may need little subsequent repetition so that it
may indeed be possible to wind down expenditure on information. Information dissemination by itself does not, however, deal with the ongoing hard core of discrepancy between the private and social benefits of prevention and therapy.

Sometimes noneconomists argue that people will take ‘ownership’ of measures to control the spread of infections and thenceforth subsidies can be lowered or ended altogether. If by ownership one means that once people are informed about the existence of a disease, its modes of transmission and the possibilities of prevention and therapy, they will do things differently, then such a view is partially consistent with an externality-based argument. If not, however, it is hard to understand what the argument means other than a somewhat naive faith in the power of habit formation as once subsidies are removed, behavior will likely revert to its original self-interested and socially suboptimal form.

**Span of the Externality**

In the case of infectious disease, people do not generate risks and external costs (and possibly benefits) equally for everyone in the whole world. It makes sense to think of the span of the externality, i.e., the range of people who may suffer costs external to someone else’s choices. People who are directly exposed to risk by someone are more likely to be close to the person putting them at risk. This closeness may be because the people put at risk have important social relationships with the people who are infected, such as family, sexual partners and friends, or because they are in close geographical proximity such as people who live, work or shop in the same neighborhoods, or commute on the same routes. Of course, someone’s failure to avoid infection can have worldwide implications through a chain of infection, as in the case of emerging infections like HIV, SARS, or avian influenza.

Naturally, what it means to be geographically close depends on the mode of transmission of the disease and intervention, something that needs documentation on a case-by-case basis. For instance, insecticide-treated bed nets protect people who sleep under them from malaria by providing a barrier. But they also kill mosquitoes (and other disease-transmitting insects) that make contact with the nets. In effect, the people sleeping under them serve as bait. The consequence is that these insects do not have the chance to bite other people who are not under nets, effects that seem to prevail up to 300 m from the people using the nets, a clear external benefit to the non-users.

Close relationships such as family or sexual partners raise several issues. At the simplest, people in this type of relationship may know about each other’s infection status through observing symptoms or medication, or through knowing who could have infected them as in the case of a sexually transmitted infection. Information of this sort in turn raises questions of strategy, in which susceptible people take actions with regard to specific people. There may be conflict over the use of condoms or testing. Families may dissolve over the infection of some of its members and the threat they pose to others. This potential for conflict raises the question of altruism versus self-interest. To what extent does someone act to avoid infecting others? If people are entirely altruistic, caring about the well-being of everyone who is affected by their decisions, then there are no externalities. In other situations they may be forced to take account of the risks they pose to others. Here one sees very starkly, possibly as a matter of life or death, the many possible considerations that arise in families.

Tuberculosis provides a good example of these family issues. It is often fatal and casually transmitted – a terrifying combination. As a result, relatives do indeed force infected members to leave the household. Understanding the motivations within the household is especially important in the case ofDOTS. One focus of debate among DOTS professionals is who should be the supervisor that ensures that the infected person complies. Cost is an issue because specialized personnel – especially medical personnel – are expensive and either they or the patient have to travel for compliance to be observed and the protocol extends over many months with daily medication. Another alternative is supervision by a family member. Here it is important to identify motivated supervisors who will get the job done. There can be several motivations: Altruistic concern for the infected family member, fear of contraction of infection, or self interest in having the infected family member return to contributing to the family by earning income or doing chores. But by the very nature of the fact that not all costs external to the infected individual occur within the family, it is unlikely that family members will always be sufficiently motivated to serve the broader social interest.

The span of the externality is important not just in determining who infects whom. It also helps think about what level of government should be dealing with the internalization of the externality. The government should encompass the people who generate and experience the external costs, otherwise the government itself will lack the motivation to internalize the externality. It is a simple principle but one that is difficult to apply when the infection spreads globally. At a global level there is no supranational government that can compel action on health and even international organizations such as the World Health Organization (WHO) depend on the cooperation of their member countries and have no independent authority. National governments may not want to share information or admit WHO or other foreign teams to investigate outbreaks and, in general, they have made no commitment to do so. This type of issue has arisen in the surveillance of avian influenza in some Asian countries during the 2000s. Conflict between different national interests also arises. For example, rich countries may decide to ban dichlorodiphenyltrichloroethane (DDT) for environmental reasons even though DDT if used for antimalarial spraying of dwellings in poor countries can be highly beneficial and without significant environmental costs if it is not diverted to agricultural use.

**Conclusion**

Taken together, what is known suggests a robust role for the externality in understanding the dynamics of infectious diseases and how to control them. But it is only one set of economic considerations in the design of policies. Insurance markets are notorious for posing their own set of market...
imperfections and are highly relevant to health where the risks are large and people are fearful. Issues involving equity also deserve important attention.

See also: Infectious Disease Modeling. Sex Work and Risky Sex in Developing Countries. Vaccine Economics. Water Supply and Sanitation

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