

Analogical Reasoning in Public Health

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Abstract:

Analogical reasoning is a valuable logical resource in a public health context. It is used extensively by public health scientists in risk assessments of new technologies, environmental hazards and infectious diseases. For its part, the public also avails of analogical reasoning when it assesses a range of public health problems. In this article, some of these uses of analogical reasoning in public health are examined. Analogical arguments have courted approval and disapproval in roughly equal measure by a long succession of logicians and philosophers. The logical features of these arguments which make them simultaneously compelling and contemptible are considered. As a form of presumptive reasoning, analogical arguments have a valuable role to play in closing epistemic gaps in knowledge. This heuristic function of these arguments is illustrated through an examination of some uses of analogical reasoning in recent public health crises. Finally, the results of a study of analogical reasoning in 879 members of the public are reported. This study reveals that lay members of the public are able to discern the logical and epistemic conditions under which analogical arguments are rationally warranted in a public health context.

1. Introduction

Analogies are a universal feature of human thinking and language. Woods (2004: 273) remarks that 'we do it all the time. Analogical characterizations come trippingly from the tongue'. The similarities between people, objects and events that form the very essence of analogies have attracted the interest of scholars in academic disciplines ranging from literature and linguistics to computer science and psychology (Guarini et al., 2009). One scientific discipline where analogies have been used extensively, but which has yet to receive much scrutiny, is public health. This paper will address this omission in the literature by examining the use of analogical arguments in a public health context. It must be emphasized from the outset, however, that this is more than an academic or philosophical exercise. Specifically, it will be contended that analogical arguments are a vital logical tool in the rational resources that one brings to the judgement of public health problems. But we must set down at a number of staging posts before we can arrive at this claim. In this section, we begin by examining some uses of analogical arguments in public health. This examination confirms the view that public health is a significant domain for the exercise of analogical reasoning. In section 2, the logical structure of this type of reasoning is addressed. The views – both positive and negative – of some of the many logicians and philosophers who have commented upon analogical arguments are considered at this point. This discussion prepares the ground for an analysis in section 3 of the rational role of analogical argument in public health judgements. In steering these judgements when knowledge is absent or lacking, analogical argument can be seen to assume a heuristic function in our rational deliberations. Finally, in section 4, the findings of a study of analogical reasoning in 879 members of the public are reported. These findings confirm a

role for this type of reasoning as a facilitative cognitive heuristic in a context of epistemic uncertainty.

To avoid logical complexity at this early stage of the discussion, I begin with a dictionary definition of analogical reasoning. The third edition of the *Collins English Dictionary* defines analogical reasoning as ‘a form of reasoning in which a similarity between two or more things is inferred from a known similarity between them in other respects’ (1991: 53). This definition captures the essential attributes of any analogy: a similarity is *inferred* from a *known* similarity between at least two things. These attributes are consistent features of the many, different examples of analogical reasoning which have found their way into public health.¹ In this context, analogical arguments have been used in relation to infectious diseases such as human immunodeficiency virus (HIV) and severe acute respiratory syndrome (SARS), as well as zoonoses² such as bovine spongiform encephalopathy (BSE). Early public health advice issued by the Centers of Disease Control (CDC) in the United States was based upon an analogy between the epidemiology of AIDS and the epidemiology of another infectious disease, that of hepatitis B (see Cummings (2004) for discussion). Specifically, similarities in the epidemiology of these diseases led investigators to conclude that the pathogen responsible for AIDS must be transmitted sexually and parenterally in exactly the same way that hepatitis B is transmitted sexually and parenterally.³ The analogical argument in this case took the following form:

MAJOR PREMISE: AIDS and hepatitis B have similar epidemiological features.

MINOR PREMISE: Hepatitis B is transmitted sexually and parenterally.

CONCLUSION: Therefore, AIDS will be transmitted sexually and parenterally.

The major premise of this analogical argument – and, indeed, the major premise of any analogical argument – incorporates substantial background knowledge. In this case, it was knowledge of the epidemiology of AIDS and hepatitis B, namely, that these diseases were at the time most prevalent among homosexual males, intravenous drug users and recipients of blood transfusions and blood-derived products (e.g. factor VIII for the treatment of haemophilia). The minor premise of this argument reflected what was by the early 1980s well-established knowledge of the routes of transmission of hepatitis B. The conclusion of this analogical argument was the basis of public health advice from the CDC to use sexual protection (i.e. condoms) and to avoid sharing needles during intravenous drug use: ‘With hepatitis B as a guide it was possible to devise, very early in the epidemic, effective guidelines for prevention of HIV infection. The recommendation to avoid sharing ‘bodily fluids’ came directly out of hepatitis B research’ (Muraskin, 1993: 109). Plant (2008: 49) describes how analogical reasoning shaped early actions in the management of SARS: ‘we considered that the SARS organism was most likely a virus and spread predominantly via the respiratory route. Hence we acted as though that was true, meaning that infection control, patient management, patient isolation and so on were all treated as though the (assumed) virus causing SARS was similar to other viruses’. The reconstructed analogical argument to which Plant refers appears as follows:

MAJOR PREMISE: SARS is similar to other viruses.

MINOR PREMISE: Other viruses are spread predominantly via the respiratory route.

CONCLUSION: SARS will be spread predominantly via the respiratory route.

It is the conclusion of this argument which provided support for the infection control measures (patient isolation, etc.) which Plant describes above. An analogy between SARS and the influenza pandemic of 1918-1919 (Spanish flu) was repeatedly employed by the World Health Organization and other agencies during the SARS outbreak of 2003 (see Zylberman (2010) for discussion of this analogy and other historical analogies involving influenza epidemics). A particularly well entrenched analogical argument during the BSE epidemic in the UK drew on an analogy between BSE and another transmissible spongiform encephalopathy (TSE) in sheep known as scrapie. This argument came to influence most risk assessments relating to BSE with ultimately disastrous consequences for human health.⁴ The argument had the following form:

MAJOR PREMISE: BSE in cattle is similar to scrapie in sheep.

MINOR PREMISE: Scrapie is not transmissible to humans.

CONCLUSION: BSE will not be transmissible to humans.

Analogical reasoning is often at the heart of the public's concerns about public health issues. Not all of this reasoning is rationally warranted even though it may appear persuasive in the contexts in which it is advanced. For example, individuals and pressure groups have used arguments such as the following to oppose the erection of mobile phone transmission masts, particularly in the vicinity of schools and childcare centres. This is despite the fact that there are significant dissimilarities in the emissions from transmission masts and electricity pylons (i.e. the major premise is problematic). Also, evidence in support of a link between non-ionising radiation from electricity pylons and childhood cancer is tentative to say the least (i.e. the minor premise is problematic):⁵

MAJOR PREMISE: Mobile phone transmission masts and electricity pylons emit non-ionising radiation.

MINOR PREMISE: Non-ionising radiation from electricity pylons has been linked to childhood cancer.

CONCLUSION: Non-ionising radiation from mobile phone transmission masts will be linked to childhood cancer.

Another recent public health issue in which analogical reasoning can be seen to play a role concerns the teratogenic effects of taking sodium valproate (Epilim) during pregnancy. From newspaper reports to blogs and the narrated experiences of parents, public discourses on this issue have increasingly involved an analogy with Thalidomide, a drug widely used in the 1960s to control morning sickness during pregnancy. In at least some of these discourses, this analogy has been used to support the view that Epilim is responsible for a range of birth and developmental anomalies in babies and children who were pre-natally exposed to this drug.⁶ This is despite the fact that significant dissimilarities surround the use of these drugs during pregnancy (e.g. Epilim is used to manage a serious, neurological disorder (i.e. epilepsy) while Thalidomide was used to treat an unpleasant, but not life-threatening, symptom of pregnancy). The analogical argument in this case unfolds as follows:

MAJOR PREMISE: Epilim and Thalidomide are prescribed medicines sometimes taken during pregnancy.

MINOR PREMISE: Thalidomide has teratogenic effects on a developing foetus.

CONCLUSION: Epilim will have teratogenic effects on a developing foetus.

A conclusive, causal link may eventually be demonstrated between the ingestion of Epilim during pregnancy and the development of conditions such as autism spectrum disorders in children. But prior to that demonstration, the above analogical argument is making the logical case for such a link on the ground that babies were exposed to these drugs during critical periods in their pre-natal development. The similarity which links Epilim and Thalidomide is nothing more than the fact that both drugs have been ingested by women during pregnancy (major premise). We have seen that Epilim and Thalidomide are used to treat different conditions. Moreover, these drugs do not contain the same active ingredients, so at best a rather loose similarity obtains between them. However, this is often the case in the analogies which are used by lay members of the public when considering public health problems. Hunt and Frewer (2001) found that subjects in the UK identified BSE as an analogue for GM food. GM food was overwhelmingly identified by these subjects as a health risk in the same way that BSE posed a health risk to humans. However, apart from the fact that BSE and GM food present an actual and potential risk, respectively, to the safety of the food we eat, these issues are dissimilar in other, significant respects (e.g. BSE is a zoonosis while GM food is the product of scientific and technological innovations). In any event, the analogical argument in this case has the following form:

MAJOR PREMISE: BSE and GM food are (actual and potential) threats to the safety of food.

MINOR PREMISE: BSE poses health risks to humans.

CONCLUSION: GM food will pose health risks to humans.

This section has presented several examples of analogical reasoning in the context of public health. Some of these examples have been used by public health agencies and experts to frame health advice to the public or to guide risk assessments. Other examples are currently used by members of the public to raise concerns about the potential health risks of an activity or agent. The content of these arguments is wide-ranging and spans infectious diseases, environmental hazards, and risks associated with new technologies and prescribed medications. Some of these analogical arguments are more rationally warranted than others. But each has been used to fulfil a specific argumentative purpose for the various experts and lay people who have advanced them. In the next section, we examine the logical and other features of these arguments which make them more or less rationally warranted in certain contexts of use. This examination will include historical and present-day views of the rational merits and logical weaknesses of analogical arguments. As well as reflecting the diverse philosophical views which exist of analogical argument, this examination will lay the ground for the discussion in section 3 of how this argument can function as a facilitative heuristic during public health reasoning.

2. Analogical argument

Thus far, analogical argument or reasoning has been defined in the following terms: a form of reasoning in which a similarity between two or more things is inferred from a known similarity between them in other respects. This definition lacks detail in a number of important respects. For example, what type of inference takes us from the known similarity to the new similarity? Can the known similarity between two things involve just a couple of properties, or should two things be similar in every conceivable respect to qualify as an analogy? In this section, we begin to add logical flesh to the bones of this definition. The

standard, logical approach to analogical argument requires first that we establish if the arguments presented in section 1 are types of deductive or inductive argument. (We have already indicated in note 1 that they are *not* figurative analogies, although figurative analogies are also commonplace in public health.) Some logicians go further than presenting an inductive characterization of these arguments and introduce the idea that analogical argument is a type of presumptive reasoning. We will consider what a presumptive approach to analogical argument involves. The issue of how analogical argument should be evaluated – as good or valid reasoning versus poor or invalid reasoning – depends on the type of argument it may be taken to be. Historically, analogical arguments have been viewed as a type of weak or sub-standard inductive argument. It is contended that this is on account of the application of inductive criteria to what is a presumptive argument,⁷ and that when assessed according to appropriate criteria, analogical arguments have rational merits which have often been overlooked or poorly characterized. These merits are fully explored within a discussion of the heuristic function of analogical arguments in section 3.

In section 1, it was described how the analogical arguments illustrated therein had been used ‘to fulfil a specific argumentative purpose’ for the experts and lay people who had advanced them. Waller (2001: 213) places a similar emphasis on the function of an analogy, on what an analogy ‘is designed to accomplish’, in his three-part classification of analogies:

‘The key to distinguishing analogies lies in examining what the analogy is designed to accomplish. A figurative analogy uses more familiar images to help us understand something that is complex, confusing, or unfamiliar; but it does not offer reasons for a conclusion. A deductive argument by analogy reminds us

of a principle which (it is assumed) we all share, and demands that we draw a consistent conclusion. An inductive argument by analogy makes a probable projection based on relevant similarities. The categorization of these analogies turns on what function they are designed to serve’.

Emissions from mobile phone transmission masts are certainly ‘complex, confusing or unfamiliar’ to most lay people. However, there is no sense in which emissions from electricity pylons are any more familiar, or that they serve as an ‘image’ which helps us understand emissions from masts. So whatever type of analogy is at work in this case, it is not a figurative analogy. Nor is it a deductive argument by analogy. What type of ‘principle’ shared by all of us is implicit in this argument? There is no principle which ordains that emissions from electricity pylons or transmission masts cause cancer. The latter are empirical facts which are established through a process of scientific investigation. One could quite easily envisage how the same emissions might have no health effects whatsoever or could cause human diseases other than cancer. The analogies in section 1 come closest to inductive analogical arguments. In each of these analogies, we are using similarities between two cases to infer a further similarity between these cases. It is a ‘probable projection’ that if electricity pylons emit non-ionising radiation which causes childhood cancer that the non-ionising radiation emitted by mobile phone transmission masts will also cause childhood cancer. But because we are dealing with a *probable* projection, we will not be surprised if the scientific community should conclude at some point that there is no causal link between the non-ionising radiation emitted by transmission masts and the development of childhood cancer. In other words, inductive analogical arguments – or at least the conclusions thereof – can be (and not infrequently are) erroneous (see note 4 for

an example of an erroneous inductive analogical argument which had particularly serious consequences for human health). A schematic model of an inductive analogical argument is presented below (Waller, 2001: 202). *D* and *E* in this model may be taken to represent two entities, people or events:

1. *D* has characteristics *e*, *f*, *g*, and *h*.
2. *E* also has characteristics *e*, *f*, *g*, and *h*.
3. *D* also has characteristic *k*.
4. Having characteristics *e*, *f*, *g*, and *h* is relevant to having characteristic *k*.
5. Therefore, *E* will probably also have characteristic *k*.

Premises (1) and (2) in Waller's formulation are represented by the major premise in the analogical arguments displayed in section 1. Waller's premise (3) is the minor premise in these arguments. Premise (4) in Waller's scheme is implicit in the analogical arguments in section 1. This premise states that a set of characteristics is relevant to a further characteristic about which we want to draw a conclusion. For example, the characteristic 'emits non-ionising radiation' is relevant to the characteristic 'causes childhood cancer' in that non-ionising radiation can trigger the genetic mutations which lead to the development of cancer.

The issue of the relevance of similarities to a further characteristic about which we want to draw a conclusion is particularly important as it is the basis upon which so many analogical arguments are shown to be wanting. For example, early laboratory and epidemiological investigations suggested that BSE and scrapie were similar in several respects. These

diseases appeared to have molecular properties, histopathological characteristics and epidemiological features in common. However, these similarities, substantial though they were, were ultimately shown to be less relevant to the issue of the transmissibility of BSE than a single dissimilarity relating to the genetics of these diseases which only strain-typing studies could reveal (see Cummings (2010) for further discussion). In this case, several similarities between BSE and scrapie which collectively had low relevance to the issue of the transmissibility of BSE were less significant to the success or otherwise of this analogical argument than a single (genetic) dissimilarity between these diseases which had high relevance to the transmissibility of BSE.

The use of 'probably' in the conclusion in (5) is in recognition of the fact that the inference in an inductive analogical argument is probabilistic in nature. This means we must always be prepared to countenance error in the case of an inductive analogical argument. Even the most strongly warranted argument may ultimately be shown to be erroneous if the evidential base upon which it is based changes at a later point in time. The probabilistic nature of the inference in an inductive analogical argument keeps us mindful of this fact.

Historically, it is as a form of inductive argument that analogical argument has come under most scrutiny from logicians. One logician in particular, John Stuart Mill, found little logical merit in this form of argument. This is how Mill characterized analogical argument in Chapter V of *A System of Logic*:

'The last of the modes of erroneous generalization to which I shall advert, is that to which we may give the name of False Analogies. The Fallacy stands

distinguished from those already treated of by the peculiarity, that it does not even simulate a complete and conclusive induction, but consists in the misapplication of an argument which is at best only admissible as an inconclusive presumption, where real proof is unattainable’.

According to Mill, the logical weakness of this argument lies in its falling short of a ‘complete and conclusive induction’. Analogical argument is little better than an ‘incomplete presumption’ which occurs in the absence of ‘real proof’. It is a sign of how much our view of this argument has changed since Mill wrote these comments that presumption is no longer levelled as a criticism of analogical argument. In fact, many present-day logicians are actively developing presumptive analyses of this argument. Indeed, it is a presumptive analysis which is most apt for the view of analogical argument as a cognitive heuristic which is developed in this paper. In expounding that view, we need to examine the features of presumption which make this concept particularly suited to performing this heuristic function. Those features divide roughly into dialectical and epistemic properties. The combination of both types of properties is required in order to understand how analogical argument functions as a heuristic in a public health context. A dialectical conception of presumption captures the scheme of critical questions which arguers pose to themselves as they attempt to assess the rational merits of analogical argument and any claim supported by means of that argument. These questions form part of the critical, rational resources that lay people draw upon when they are required to arrive at judgements about public health problems. An epistemic conception of presumption captures features of this concept which make it particularly well suited to the uncertainty of the contexts in which public health deliberations proceed. In these contexts, we often lack the knowledge that is required to

assess the risks posed by certain agents and activities. Yet, we must still make assessments of those risks. Epistemic presumption is the rational resource which permits us to arrive at these judgements in the absence of knowledge. We consider both approaches to presumption in this section.

The concept of presumption is typically found within a critical discussion in which two parties are contesting a certain thesis or statement. At any point in this discussion, only one of these parties can lay claim to the presumption, while the other party has a responsibility to discharge a burden of proof: 'When one is engaged in making the case for a conclusion it is very important in practice to be clear on which side the *Presumption* lies, and to which belongs the *Burden of Proof*' (Hamblin, 1970: 170; italics in original). When an arguer succeeds in discharging a burden of proof onto his opponent, the presumption returns to his side of the discussion. It is within the dialectical context of a critical discussion that Walton (1996: 80) wishes to frame the argument from analogy: 'argument from analogy is characteristically used to shift a burden of proof in a critical discussion of an issue that has two sides'. An opponent in argument can quickly discharge his or her burden of proof if it can be demonstrated that the argument from analogy does not hold up in some respect. To this end, he or she can draw upon a number of critical questions to reveal any weaknesses in this argument, should they exist. Walton (1996: 79) characterizes these questions as follows:

1. Are C_1 and C_2 similar, in the respect cited?
2. Is A true (false) in C_1 ?

3. Are there differences between C_1 and C_2 that would tend to undermine the force of the similarity cited?

4. Is there some other case C_3 that is also similar to C_1 , but in which A is false (true)?

Applied to the example of the transmission masts, the opponent who identifies that the emissions from electrical pylons are not the same as the emissions from masts has posed the third of these critical questions. In so doing, he or she has discharged the burden of proof onto the proponent of the analogical argument. The proponent of this argument must either demonstrate that the emissions from the two types of installation are not dissimilar in the respect suggested or accept that there is no basis for the claim at the centre of the argument (i.e. it is false that emissions from transmission masts cause childhood cancer). The third critical question is not the only way in which the burden of proof created by the analogical argument may be discharged. The second critical question could lead an opponent to ask if it really is the case that emissions from electricity pylons cause childhood cancer – we saw above that this cannot be definitively stated. Alternatively, an opponent may respond to the argument from analogy by posing the fourth critical question. In this case, the opponent discharges the burden of proof by presenting a counter-analogy. For example, it may be argued that electricity sub-stations have been found to produce the same emissions as electricity pylons but with no evidence of them causing childhood cancer. With each critical question that is posed, the rational grounds of the contested claim in the argument are laid bare. A presumptive analysis of analogical argument accounts for this rational development in terms of the transition between presumption and burden of proof in a critical discussion.

Walton's emphasis on the role of critical questions in analogical argument will be central to the view of this argument as a cognitive heuristic which will be developed in section 3. For integral to this view is the idea that lay people are capable of raising and addressing such questions even if they do not do so on particular occasions or in certain settings. Valuable as Walton's insights are, they do not address epistemic aspects of presumption which are also vital to the heuristic function of analogical argument. On these aspects, the work of Nicholas Rescher makes an important contribution. Rescher does not deny the dialectical character of presumption.⁸ However, even as he acknowledges this dialectical character, Rescher is at pains to emphasize the epistemic nature of presumptions and their role in rational (principally scientific) inquiry. Rescher (2006: 6) describes presumptions as low-grade data which cannot lay claim to knowledge, although they may eventually become knowledge claims:

'[P]resumption is certainly not knowledge: we do not *know* what we merely *presume* to be so. As an informative resource its standing is quite different from that of knowledge.' (italics in original)

Although it is not knowledge, a presumed thesis is not thereby without any rational basis. When I presume that *p*, I am indicating that *p* has some rational standing even if I am not prepared to commit wholeheartedly to that proposition. This standing may be on account of the provenance of a thesis. For example, there is a presumption of veracity in favour of theses derived from the senses but not for theses derived from telepathy or astrology. So even though I may be mistaken on occasion about what I see and hear, I can at least presume theses from my visual and auditory faculties to be true in a way that I cannot for

theses obtained by telepathy or from astrology. Because presumptions are accepted on a tentative basis, circumstances can arise in which they are shown to be false or erroneous. It then becomes necessary to reject or overturn them. The defeasibility of presumptions in the face of countervailing considerations makes this possible without incurring wider revisions in our body of knowledge. (Presumptions do not have a foundational role in our knowledge so error does not necessitate a wider revision of knowledge.) Of course, presumptions can only be overturned by the emergence of contrary evidence if they are sensitive to features of the contexts in which they are found. Context sensitivity is thus an important attribute of this epistemic concept. Presumptions also display an orientation to action in that they permit the progress of an inquiry where a demand for knowledge would serve only to stall an inquiry. These features of epistemic presumption – their low-grade status, rational standing, defeasibility, context sensitivity and orientation to action – receive philosophical discussion and analysis in Rescher (2006). Their role within an important public health problem, the emergence of BSE in British cattle, is examined at length in Cummings (2002, 2005, 2009, 2010, 2011, 2012a, 2012b).

3. Analogical argument as a heuristic

Thus far, analogical argument has been described as a type of presumptive argument. As a presumptive argument, the premises, conclusion and inference of an analogical argument have the status of presumptions, with all that this entails (e.g. defeasibility, context sensitivity). Also as a presumptive argument, analogical argument draws on the dialectical and epistemic properties of presumptions which were described in section 2. The task for the current section is to demonstrate how these same properties contribute to analogical argument as a heuristic during reasoning about public health problems. To dialectical and

epistemic properties of presumption we must add cognitive and evolutionary considerations. This is because in presenting analogical argument as a heuristic, we are characterizing it as a cognitive procedure. We will see that the function of this procedure is to provide a type of cognitive shortcut through our deliberations in public health (and elsewhere). Analogical argument is particularly well suited to this cognitive function, it is contended, because it is an evolutionary adaptation on the part of human rationality to the problems of epistemic uncertainty and a lack of knowledge. Put simply, we cannot survive as organisms within environments that are characterized by pervasive uncertainty, if we lack cognitive resources which are equipped to cope with that uncertainty. Analogical argument is one part of the rational toolkit which evolution has bestowed on us and which makes us cognitively fit for our environment. Similar cognitive and evolutionary claims have been advanced elsewhere,⁹ and will be discussed further below. But for our purposes, we must return to the claim that analogical argument has a heuristic function during public health reasoning. We will now support this claim by addressing the following issues: (1) there must be some *purpose* for which analogical argument is advanced; (2) there must be some *means* by which analogical reasoning is performed; and (3) there must be some *outcome* to this reasoning, where 'outcome' is broadly construed to include any gain in knowledge or practical gain.

In relation to (1), the purpose for which an analogical argument is advanced in a public health context is to facilitate judgement-making in the absence of knowledge. On an individual level, these judgements may concern one's personal risk of developing skin cancer or the decision to vaccinate one's children against infectious disease. On a larger scale, they may also involve assessments of the safety of certain foods for human

consumption or the risks of exposure to carcinogens from chemical plants and nuclear facilities. What all these judgements have in common is their reliance on specialized or expert knowledge which is lacking on the part of the lay person. Yet, these are still judgements which we are all required to make to a greater or lesser extent as part of our daily deliberations. It is against this backdrop that analogical argument functions as a quick and effective heuristic, or as a pragmatic 'rule of thumb', that guides judgement-making by bypassing gaps in knowledge. The analogical template made possible by a well-known infectious disease or a long-established technology allows the lay person to perform a much simpler cognitive operation than would otherwise be the case. By identifying a small number of salient properties in a new and unknown domain based on these same properties in the template, the lay person can arrive at a rationally warranted judgement in the absence of knowledge of a range of complex scientific issues. In effect, the lay individual is setting aside technical and other considerations which are not part of his or her current knowledge state. This lack of knowledge may simply reflect one's educational background (people may not have had education and training in the requisite disciplines), or it may be on account of cognitive limitations (even with training, many of these technical and scientific issues will not be readily understood by people).

We are not quite done with the purpose for which analogical argument is used in our cognitive deliberations. Clearly, there is a survival advantage for the organism that can make accurate judgements about an issue using a minimum of cognitive resources. Because such an organism is not expending all its cognitive resources in forming judgements, it is then free to direct these resources to the solution of other problems in its environment. Heuristics – and analogical argument to the extent that it is a heuristic – are ideally suited to

the type of cognitive efficiency which is described here. There is a considerable cognitive economy to be had in analogical reasoning. This is because cognitive resources such as memory and attention are employed to the minimal extent possible when large bodies of expert knowledge do not have to be stored by a cognitive agent, and when multiple features of a new situation are not the focus of an agent's attention. Moreover, it is a common misconception that the reduced cognitive processing which attends the use of heuristics must necessarily lead to a reduction in the accuracy of the judgements which are arrived at by means of those heuristics. Quite apart from being less accurate than systematic reasoning processes, simple heuristics have been found to perform comparably to more complex algorithms. Todd and Gigerenzer (2000: 727) state that:

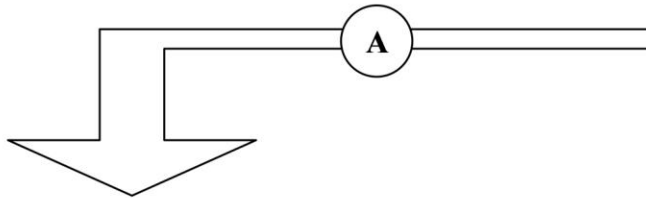
[W]e show how simple building blocks that control information search, stop search, and make decisions can be put together to form classes of heuristics, including: ignorance-based and one-reason decision making for choice, elimination models for categorization, and satisficing heuristics for sequential search. These simple heuristics perform comparably to more complex algorithms, particularly when generalizing to new data.'

So, the purpose of analogical argument is not simply to facilitate judgement-making in the absence of knowledge, but also to conserve cognitive resources without thereby compromising the accuracy of judgements. In reducing the number and range of cognitive resources which must be directly applied to judgement-making, analogical argument also embodies a considerable economy in the cognitive domain.

In relation to (2), the means by which analogical reasoning is performed is twofold and corresponds to the dialectical and epistemic properties of this presumptive argument. The dialectical features of analogical argument enable this argument to function as a form of systematic reasoning which is slow and deliberative in nature. During systematic reasoning, a cognitive agent interrogates the rational grounds of an analogical argument by addressing a series of critical questions. These questions challenge us to consider features of this argument which are integral to its rational warrant. They include: Is the purported similarity between two entities or situations a sufficient basis for the conclusion of an analogical argument? Can a third entity or situation be brought forward which is similar to the first, but in which the inferred property does not hold? (see Walton (1996) for further discussion of critical questions). In addressing these critical questions, and weighing up the significance of responses for the rational warrant of an analogical argument, a cognitive agent must attend to every detail that has a bearing on an issue. But this type of systematic reasoning is achieved at considerable cost to a cognitive agent. Such an agent must access memory, assimilate information and assess (often conflicting) evidence. Each of these cognitive resources incurs a cost for the agent who must also devote more processing time to the deliberation of an issue. Given this additional cost and processing time, the dialectical form of analogical argument can only be implemented within certain discursive contexts. One such context is an inquiry in which investigators usually have considerable time to examine all aspects of an issue before arriving at a judgement (e.g. the three-year public inquiry into BSE in the UK). The dialectical form of analogical reasoning is illustrated by arrow A (a probabilistic inference) in Figure 1:

**SYSTEMATIC
REASONING
(Arrow A)**

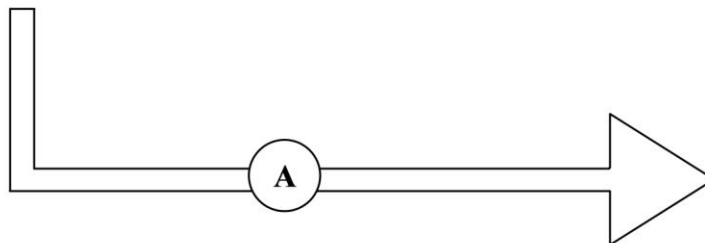
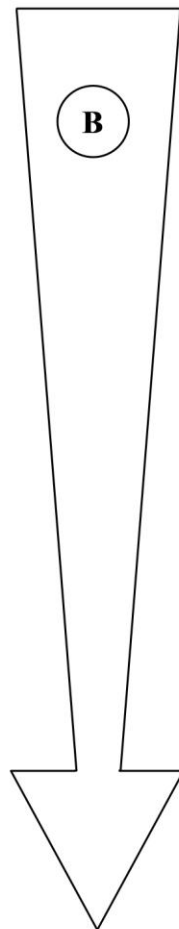
**HEURISTIC
REASONING
(Arrow B)**



MAJOR PREMISE:
A and B display properties x and y
MINOR PREMISE:
A displays property z

CRITICAL QUESTIONS:

- (1) Are A and B truly similar in respect of x and y ? Example: Are emissions from mobile phone transmission masts actually similar in their electromagnetic properties to emissions from electricity pylons?
- (2) Are properties x , y and z linked in some way so that having x and y is relevant to also having z ? Example: Is the property 'emits non-ionising radiation' relevant to the property 'develops childhood cancer'?
- (3) Is there some other entity or situation which is similar to A but in which z is false? Example: Is there another type of electrical installation which also emits non-ionising radiation but which does not cause childhood cancer?



CONCLUSION:
B displays property z

Figure 1: Analogical argument as systematic and heuristic reasoning.

However, there are many situations in public health and elsewhere in which decisions must be taken against a backdrop of considerable urgency (e.g. the decision how best to contain a rapidly escalating outbreak of infectious disease). In these cases, agents must abandon the use of critical questions and arrive at a judgement through a quicker and less costly cognitive route than that which is afforded by systematic reasoning. This route involves the use of heuristics such as analogical argument. Heuristics are specially adapted to arrive at quick and effective solutions to problems. It is the epistemic properties of analogical argument which permit its use as a heuristic. It will be recalled from section 2 that presumptions exhibit epistemic features which make them well suited to cope with the uncertainty of public health and other contexts. It is these features of presumption which underpin the use of analogical argument as a heuristic. As presumptive theses, the premises in an analogical argument are accepted on a tentative basis – there is no costly expansion of the rational grounds of these premises such as occurs in systematic reasoning. Also as presumptive theses, the premises in an analogical argument licence actions in the practical sphere often in advance of cognitive deliberations – the type of intensive cognitive deliberation that is typical of systematic reasoning does not occur. As a presumptive thesis, the conclusion of an analogical argument may be overturned without necessitating a wider revision of our body of knowledge and beliefs. Belief revision is costly in cognitive terms and is only undertaken *in extremis*. This cost is largely averted when analogical argument is used as a heuristic. Clearly, a different (and less costly) form of analogical argument which draws on epistemic properties of presumption must also be included within our rational resources. This heuristic form of analogical argument is represented by arrow B (a probabilistic inference) in Figure 1.

In relation to (3), it is not difficult to demonstrate a clear outcome from the use of analogical reasoning in a public health context. Outcome is construed here as any demonstrable epistemic and practical gain that accrues from the use of analogical argument. In terms of epistemic gains, analogical argument functions as a productive source of new claims which can advance an inquiry. The analogical arguments displayed below were vital in progressing key aspects of the scientific inquiry into BSE at a time when little was known about this new disease (Cummings, 2010: 94-95). These analogical arguments supported presumptive conclusions concerning the transmission routes, host range and pathogenesis of BSE. These conclusions contributed to the developing knowledge base on BSE until such times as results from experimental studies were forthcoming:

Transmission routes:

MAJOR PREMISE: BSE is similar to scrapie in sheep.

MINOR PREMISE: There is maternal and lateral transmission of scrapie in sheep.

CONCLUSION: There will be maternal and lateral transmission of BSE in cattle.

Host range:

MAJOR PREMISE: BSE is similar to scrapie in sheep.

MINOR PREMISE: Scrapie has been transmitted to marmosets, mink, goats, mice, sheep and hamsters.

CONCLUSION: BSE will be transmitted to marmosets, mink, goats, mice, sheep and hamsters.

Pathogenesis:

MAJOR PREMISE: BSE is similar to scrapie in sheep.

MINOR PREMISE: In scrapie, infectivity does not reach the brain or spinal cord in the first 6 months of life.

CONCLUSION: In BSE, infectivity will not reach the brain or spinal cord in the first 6 months of life.

As well as contributing to the knowledge base on BSE, these analogical arguments also had practical implications for the containment of the disease. Pathogenesis studies at the Central Veterinary Laboratory would enable scientists to establish which bovine tissues were infective and, therefore, needed to be removed from the human food chain. However, such is the length of the incubation period of transmissible spongiform encephalopathies that these studies would take many months and even to complete. A significant ban to protect public health – the human Specified Bovine Offal (SBO) ban – could not be delayed until results from these studies became available. In the absence of experimental results, public health officials needed to establish which bovine tissues were candidates for inclusion in the ban. Analogical arguments based on scrapie were used to establish the terms of the SBO ban. A further practical gain achieved through the use of these analogical arguments was the establishment of research priorities. Experimental transmission studies were used to determine the host range of BSE. However, these studies were particularly expensive to undertake and risked diverting funding from other important areas of veterinary research. Some means needed to be found of narrowing the potentially large range of species for inclusion in these studies. That means was analogical argument. Finally, farmers who had breeding cattle required urgent advice on how best to reduce the risk of BSE transmission from dams to their calves. In the early months of the BSE epidemic, scientists lacked

evidence relating to the maternal transmission of the disease. In the absence of evidence, advice to farmers from the Ministry of Agriculture, Fisheries and Food was based on what was known about maternal transmission in scrapie. From giving advice to farmers and instituting public health bans to establishing research priorities, analogical argument resulted in a number of important, practical gains during the UK's BSE epidemic.

4. Study of public health reasoning

The largely philosophical considerations examined so far lead one to ask if systematic and heuristic variants of analogical argument have psychological reality in the reasoning of lay people. This question was the focus of a recent study of public health reasoning by members of the public. Given the dependence of systematic and heuristic variants of analogical argument on quite distinct properties of this argument – dialectical and epistemic properties, respectively – this question naturally resolves itself into an examination of the role of these properties in subjects' logical judgements on public health problems. To this end, it was predicted that subjects would be able to identify the dialectical and epistemic conditions which confer rational warrant on analogical argument and, by the same token, the conditions under which this argument is weakly warranted. It was also predicted that subjects would appeal to the dialectical and epistemic properties of analogical argument to support their validity ratings of these arguments. Analogical argument was one of four arguments examined in the study. The three remaining arguments, which included arguments from ignorance and authority and circular argument, are reported elsewhere (Cummings, 2013, 2014a, 2014b, 2014c). What unites these arguments is their capacity to function as heuristics during reasoning about public health problems. This is despite the fact that each has endured a long and inglorious history in logic as an informal fallacy.¹⁰ A

detailed discussion of this investigation cannot be undertaken in the present context. This section will, therefore, describe in brief the method used in the study and report some of its quantitative and qualitative results. For further discussion of the rationale for the study and an analysis of its findings, the reader is referred to Cummings (2014a).

A total of 879 subjects participated in the study. All subjects were between 18 and 65 years of age. Male and female subjects from any ethnic or socioeconomic background and of any educational level were admitted to the study (see Table 1 for subject characteristics). For the most part, the participation of subjects was secured through a series of formal recruitment activities conducted in local hospitals, large retail outlets and private health clubs in the East Midlands region of the UK. There was no financial or other incentive offered to subjects for their participation in the study. Subjects received a brief explanation of the study prior to giving their agreement to participate in it. Each subject was presented with eight public health scenarios in the form of written passages in a postal questionnaire. The questionnaire was completed anonymously in the subject's own time. Scenarios described a range of actual and non-actual public health problems. Background beliefs and knowledge are known to influence reasoning.¹¹ The inclusion of non-actual scenarios, about which subjects were less likely to have prior beliefs, served to control this effect to some extent. Each scenario had been examined by two public health consultants before the start of the study in order to assess their plausibility as public health problems. Two academic linguists also examined the passages in order to assess their comprehensibility to the lay person. On the basis of these pre-study checks, all passages were considered to be plausible and comprehensible.

Four passages were used to examine analogical arguments: (1) the use of hepatitis B by the Centers for Disease Control in the US as a model for HIV/AIDS health advice; (2) an investigation by epidemiologists of illness related to chemicals in drinking water; (3) the use of scrapie by British scientists to assess the risk of BSE to human health; and (4) a study by epidemiologists of the health effects of a new arthritis drug. These passages were carefully constructed in order to represent a range of conditions which subjects might deem significant in an assessment of the rational warrant of analogical arguments. Four questions followed each passage. Two of the questions required a yes/no response or a response of a few words, and could be answered on the basis of information explicitly presented in the corresponding passage. These questions were intended to give respondents the impression that they were engaging in a reading comprehension task and thus served to distract subjects from the main purpose of the study. A third question was intended to establish if subjects accepted the conclusion of an analogical argument. Conclusions could be rated as valid, moderately valid or not valid at all, where 'validity' was intended in a mundane (and not a strictly deductive) sense. A fourth question asked subjects to explain their answer to this question. It was intended to elicit an open response from which information could be gleaned about the factors that had been significant in the individual subject's reasoning. The following passage and questions examined an analogical argument with the features <actual scenario, strong analogy>:

In 1981, reports of a rare form of pneumonia in five previously healthy homosexual males treated in three Los Angeles hospitals appeared in the *Morbidity and Mortality Weekly Report* in the United States. Little did the global scientific community know then that it was witnessing early cases of what was

to become known as AIDS. Initially, the Centers for Disease Control (CDC) did not know what pathogen was responsible for this new disease. Before the HIV virus was even identified, the CDC issued advice on how the public could best protect itself against AIDS. This advice included information about safe sex practices and the avoidance of needle sharing by intravenous drug users. The CDC's advice was based on its belief that the causal agent of AIDS must be a blood-borne virus given similarities between the population groups who were developing AIDS and those groups that were susceptible to another blood-borne virus, hepatitis B. These groups were homosexual males, intravenous drug users and recipients of blood transfusions. CDC scientists had extensive experience of the hepatitis B virus by the time the first cases of AIDS emerged. Consequently, they had little difficulty adapting public health information used for hepatitis B to address this new disease that confronted them.

(a) Did the first cases of AIDS in the US appear in hospitals in San Francisco?

(b) The CDC believed that AIDS was caused by a blood-borne virus. Was the CDC's belief (i) valid (ii) moderately valid or (iii) not valid at all (please circle answer)?

(c) In which population group were the first five cases of AIDS documented?

(d) Please explain your response to (b).

As shown in Table 2, strong analogies were consistently rated as more valid by subjects than weak analogies. This was evident across both actual and non-actual scenarios. In this way, 51.4% of subjects rated a strong analogy as valid and only 10.3% rated a weak analogy as valid within an actual scenario. Within a non-actual scenario, a strong analogy was rated as valid by 49.1% of subjects and a weak analogy was rated as valid by 5.2% of subjects. The highest ratings of 'not valid at all' were consistently found for weak analogies across both actual and non-actual scenarios. Weak analogies were rated as not valid at all by 74.5% of subjects (non-actual scenario) and 51.9% of subjects (actual scenario), while only 9.4% of subjects (non-actual scenario) and 7.3% of subjects (actual scenario) rated strong analogies as not valid at all. There appeared to be negligible percentage differences in subject ratings of validity across actual and non-actual scenarios. For example, responses to the passages which examine strong analogies were as follows: actual scenario (51.4% valid; 41.3% moderately valid; 7.3% not valid at all) and non-actual scenario (49.1% valid; 41.5% moderately valid; 9.4% not valid at all).

More significant in the present context was the qualitative data obtained from subjects. This data provided support for the claim that subjects are able to identify dialectical and epistemic properties of analogical arguments. Moreover, they appear to attach quite different roles to these properties within their reasoning. Many comments reflected a concern on the part of respondents to 'test' analogical arguments by subjecting their premises to critical questions. In relation to the major premise, the strength of the presumed similarity between two entities (often, infectious diseases) was variously interrogated. In some cases, this similarity was judged to be persuasive but not conclusive (comment 1). This suggested the application by subjects of a normative standard beyond

that of mere persuasion. Where a similarity was judged not to be conclusive, subjects often stated that it provided an inadequate ('flawed') basis for a conclusion based upon it (comment 2). Where a similarity was evaluated in positive terms, respondents often indicated this through expressions of scientific validity (comment 3):

(1) 'Whilst similarities are persuasive, they aren't conclusive, so I opted for "moderately valid"' (40-year-old, university educated, White British female).

(2) 'At this time it was not conclusive that BSE and scrapie were related diseases – it was only a suggestion, therefore the reasoning behind the suggestion that BSE would not transmit to humans was flawed' (32-year-old, university educated, White British female).

(3) 'the CDC would seem to have made a scientifically based connection between an existing disease and a new one' (49-year-old, university educated, White Irish female).

The minor premise of analogical arguments was also the focus of dialectical evaluation. The minor premise of the analogical argument based on scrapie – 'scrapie is not transmissible to humans' – was challenged by several respondents. Technological and medical limitations during the 250-year history of scrapie, it was argued, weakened the rational warrant of this premise (comment 4). For other respondents, the similar epidemiological features of BSE and scrapie were not a sufficient basis for a conclusion about the transmissibility of BSE

(comment 5). It was clear that for these respondents, the analogical argument based on scrapie failed to adequately address the second critical question in Figure 1 above:

(4) 'how do we know that scrapie may not have transmitted to humans in 250 years as technology has not been advanced over the 250 years and people died of unknown conditions' (37-year-old, secondary school educated, White British female).

(5) 'it doesn't seem to me a safe assumption that because two diseases are 'related' they will necessarily act in the same way as far as transmission to humans is concerned' (62-year-old, university educated, White British male).

Some respondents used the analogy between BSE and scrapie to draw a different (typically contrary) conclusion about the transmissibility of BSE to humans. Although this did not qualify as a counter-analogy – respondents still reasoned from the analogy between BSE and scrapie described in the passage – it did reveal considerable logical acuity on the part of subjects as they proceeded to address critical questions of this argument. The response of one subject is shown below (comment 6). The analogical argument implicit in this response is reconstructed alongside it:

(6) 'If cows eating sheep tissue products could develop BSE, then could humans not develop a form of the disease by eating BSE infected meat?' (32-year-old, university educated, White British female).

MAJOR PREMISE: BSE in cattle is similar to scrapie in sheep.

MINOR PREMISE: Scrapie is transmissible to other species.

CONCLUSION: BSE will also be transmissible to other species (viz., humans).

Epistemic properties of analogical arguments were also frequently commented upon by subjects. It was described in section 2 how the presumptions that constitute the premises and conclusions of these arguments are low-grade data. Respondents variously indicated this by describing the conclusions of these arguments as ‘suggestions’ (comment 2) or ‘assumptions’ which are not based on ‘rigorous scientific evidence’ (comment 7). In a smaller number of cases, respondents used expressions such as ‘guess’ (comment 8) and ‘only an analogy’ (comment 9) to indicate that these conclusions had a low-level epistemic standing. The expression ‘leap of faith’ (comment 10) suggested that for some respondents, analogical conclusions had no rational standing whatsoever (but see section 2 above):

(7) ‘It’s a reasonable assumption given what they knew about hepatitis B, but wasn’t based on rigorous scientific evidence at that time’ (51-year-old, university educated, White Australian female).

(8) ‘Unless the diseases were one and the same, it could surely not be concluded that they would behave in exactly the same way. At best the conclusions would be a guess’ (46-year-old, secondary school educated, White British female).

(9) 'comparison with hepatitis B is only an analogy – therefore there must be a degree of uncertainty about the conclusion drawn' (46-year-old, university educated, White British male).

(10) 'I can see the point but it is a leap of faith, a big assumption and not based on BSE evidence' (29-year-old, university educated, White British male).

In section 2, it was described how the low-grade status of presumptions enabled scientists to embark on an inquiry or investigation when a demand for knowledge would serve only to stall inquiry. Several respondents captured this function of analogical argument through the use of expressions such as 'good starting point' (comment 11) and 'valid initial start' (comment 12):

(11) 'I think it was a good starting point as the chemical compound in question was identified as being similar to the chemical identified in causing the ailments stated' (29-year-old, university educated, Black British Caribbean female).

(12) 'This was a valid initial start to the investigation, until the actual cause could be isolated' (48-year-old, university educated, White British female).

Although analogical arguments were judged to be a good starting point for an inquiry, respondents stated that they should not be pursued at the expense of other sources of evidence. It was described in section 2 how presumptions in analogical arguments have a high potential for error given their tentative nature. For this reason, it is important to

consider other sources of evidence in an inquiry. Several comments suggested that respondents were keenly aware that analogical arguments must not be considered to the exclusion of other evidence. Respondents remarked that an investigation must 'focus on all sources' (comment 13). Although analogical arguments are a 'fair starting point' in an inquiry, it must 'move outwards' (comment 14). These arguments should not form the 'only line of enquiry' (comment 15):

(13) 'I have circled not valid at all, because the epidemiologists have been sent to do an extensive enquiry and not just one source that is singled out. They need to focus on all sources just in case one has slipped through the net (so to speak)' (51-year-old, secondary school educated, White British female).

(14) 'It is a fair starting point but only such. The investigation should have then moved outwards' (50-year-old, university educated, White British male).

(15) 'It seems logical to use existing knowledge about another similar chemical to investigate whether the second chemical was the source of the health problems in the area. I suppose it should not have been the only line of enquiry though, and other possibilities should also have been investigated' (29-year-old, university educated, White British female).

Finally, an examination of other sources of evidence brings with it the possibility that we may have to reject the conclusions of analogical arguments. As a form of presumptive reasoning, analogical arguments are inherently defeasible and are readily overturned by the

emergence of 'new information' in an inquiry (comment 16). This was a decisive consideration in the reasoning of several subjects in the study:

(16) 'belief is based on the knowledge available at the time and can be subject to change due to new intervening factors/information. So at the time the belief was 'valid' subject to possible future information affecting it' (51-year-old, university educated, White European female).

5. Concluding remarks

This paper has contended that analogical argument plays a vital role in the logical judgements of experts and lay people on matters relating to public health. That role was characterized as a cognitive heuristic. Analogical argument was shown to function as a quick and effective shortcut through public health problems by closing gaps in our knowledge. These gaps arise because most public health problems involve expert knowledge and levels of specialization which are beyond the competence and experience of lay people. Yet, people must still undertake judgements about these problems if only to assess their implications for their own health. Within this context, analogical argument was seen to cut through the uncertainty created by a lack of knowledge and, in doing so, arrive at solutions to these problems. This was at all possible because of the presumptive nature of this argument. As a form of presumptive reasoning, analogical argument was shown to exhibit both dialectical and epistemic properties. These properties are significant in that they are essential to systematic and heuristic versions of analogical argument, respectively. Dialectical properties capture the use of critical questions to interrogate the rational basis of analogical argument. This form of reasoning is slow and deliberative as it attends to every

detail. It is also a cognitively costly form of reasoning. Epistemic properties are essential to the use of analogical argument in heuristic reasoning. This form of reasoning is quick and cognitively efficient as it bypasses the critical questions that are integral to systematic reasoning. An investigation of 879 members of the public revealed that people appeal to both sets of properties in their logical judgements about public health problems.

It is pertinent to ask what implications, if any, this view of analogical argument has for the practice of public health. It is essential to the success of public health interventions that people make informed choices based on advice issued by public health officials and scientists. In communicating this advice, public health experts tend to conflate the public's (very real) lack of knowledge about public health problems with a lack of a rational capacity to engage in logical judgements about those problems. If this study has demonstrated anything, it is that lay members of the public are attune to the logical conditions under which analogical arguments are more or less rationally warranted. This includes dialectical and epistemic properties of these arguments and the functions of these properties within systematic and heuristic reasoning. To the extent that lay people would appear to have this rational capacity, it seems advisable for practitioners to attempt to exploit it during public health communication. In order to increase the public's understanding of, and willingness to participate in, public health interventions, experts should make explicit the role of analogical reasoning in their advice when it comes to framing public health messages. Moreover, public health experts who pursue this course of action can have reasonable confidence that lay members of the public possess the requisite rational resources to evaluate this reasoning. This confidence may also encourage a candid approach to informing the public about the conditions under which a currently strongly warranted analogical argument may

be weakened by future developments (e.g. emergence of new and contrary evidence). These conditions are less likely to be greeted by alarmist reactions in a public which is versed in rational appraisal. The view that lay members of the public are rational agents, even if not always knowledgeable agents, may or may not lead to a more effective form of public health communication. But even if it does not lead to improved communication, public health will have taken an important step forward in terms of understanding the rational capacities of the populations it serves.

NOTES

1. It should be emphasized that in discussing analogies in public health, there are many analogies that are not of relevance to the current discussion. These analogies have a figurative, ethical or descriptive function rather than a logical purpose. They include an analogy between infectious diseases and war (De Grandis, 2011), between dose-response in toxicology and public health areas such as diet, alcohol and physical activity (Whitelaw, 2012), and the use of normative analogies in establishing ways in which new and emerging technologies such as umbilical cord blood biobanking should be used (Hofmann et al., 2006). These analogies do not have an argumentative function, although they may perform other, equally important roles: 'Figurative analogies do not argue, though they may elucidate' (Waller, 2001: 200).

2. A zoonosis is any disease which transmits to humans from a lower vertebrate. In transmitting from cattle to humans, BSE is a zoonotic condition.

3. Parenteral transmission is defined as that which occurs outside of the alimentary tract, such as in subcutaneous, intravenous, intramuscular and intrasternal injections (Berkley, 1991).

4. On 20 March 1996, Mr Stephen Dorrell, the then Secretary of State for Health, announced to British Parliament that BSE was responsible for a new form of Creutzfeldt-Jakob disease (CJD) in several young people. This was the first public acknowledgement that BSE had

transmitted to humans. It marked the beginning of a human health crisis which is continuing to this day.

5. Wood (2006: 361) states that ‘the characteristics of the electric and magnetic fields associated with high voltage power lines are quite different from the radiofrequency emissions from mobile telephony systems’. Wood (2006: 364) also remarks that ‘[t]aken individually, some, but by no means all [...] studies show evidence of raised cancer risk and B-field exposure’. The B-field is one of two types of field associated with electrical power systems.

6. An example of public discourse in which a logical similarity is made between Thalidomide and Epilim includes the following. On 11 March 2013, the blog of Paul Flynn (Labour Member of Parliament for Newport West in Wales) remarked of Epilim that ‘[i]t could be worse than Thalidomide *for the same reasons*’. This italicised expression attests to the well-established causal link between the ingestion of Thalidomide during pregnancy and the development of birth defects.

7. The tendency to apply an incorrect standard to the evaluation of arguments, and then condemn arguments as fallacious when they fall short of this standard, has been widespread in logic and argumentation. Finocchiaro (1981: 15-16) remarks of this practice as follows: ‘[L]et us examine the second element of textbook accounts of fallacies, the description of various devices which I wish to call by the neutral term of “disputed practices”. One problem with these descriptions is that they are usually prejudicial in the sense that their fallaciousness is built right into their description...There is a pattern in these

biased descriptions, and it is the following. If the disputed practice is a type of inductive argument, namely one claiming that the conclusion is only strongly, but not conclusively, supported by the premises, then the practice will be described as a type of deductive argument, namely one claiming that the conclusion is conclusively supported by the premises. If the disputed practice is a type of what might be called a partial argument, namely one claiming that the conclusion is only partly, but not too strongly supported by the premises, then the practice will be described as a type of allegedly inductively strong argument...the pattern (or shall I say the fallacy?) is that of exaggerating the strength of the connection claimed between various assertions...’.

8. Godden and Walton (2007) attribute the first detailed account of presumption in a dialectical framework to Rescher (1977).

9. The reader is referred to Walton (2010) for an excellent discussion of these cognitive and evolutionary issues as they relate to informal fallacies such as the argument from expertise. Gigerenzer and Brighton (2009) and Gigerenzer (2000) conduct a wide-ranging discussion of these cognitive and evolutionary issues in relation to heuristics.

10. More recent analyses have described non-fallacious variants of *petitio principii* (begging the question), *argumentum ad ignorantiam* (the argument from ignorance), and *argumentum ad baculum* (the argument from the stick or appeal to force), among other informal fallacies (Cummings, 2000, 2012c; Walton 1985, 1992; Woods 1995, 2004).

11. It is expected that background knowledge and beliefs will affect the information that subjects attend to in the passages and the significance that subjects attach to this information. As Klahr (2000: 30) remarks: 'When people are reasoning about real world contexts, their prior knowledge imposes strong theoretical biases...These biases influence not only the initial strength with which hypotheses are held – and hence the amount of disconfirming evidence necessary to refute them – but also the features in the evidence that will be attended to and encoded'.

	SUBJECT CHARACTERISTICS
AGE	Average: 43.8 years Range: 18-65 years
GENDER	Male: 292 subjects Female: 587 subjects
EDUCATION	University level: 589 subjects Secondary school level: 290 subjects
ETHNICITY	White British: 789 subjects White Irish: 30 subjects Asian or British Asian Indian: 15 subjects Asian or British Asian Pakistani: 4 subjects Black or Black British Caribbean: 3 subjects Black or Black British African: 3 subjects Mixed: White and Black Caribbean: 1 subject Mixed: White and Black African: 1 subject Mixed: White and Asian: 1 subject Other: 32 subjects

Table 1: Subject characteristics

ANALOGY SCENARIO	STRONG	WEAK
ACTUAL	<p>Strong analogy; Actual scenario</p> <p>Results: Valid: 51.4% Moderately valid: 41.3% Not valid at all: 7.3%</p>	<p>Weak analogy; Actual scenario</p> <p>Results: Valid: 10.3% Moderately valid: 37.8% Not valid at all: 51.9%</p>
NON-ACTUAL	<p>Strong analogy; Non-actual</p> <p>Results: Valid: 49.1% Moderately valid: 41.5% Not valid at all: 9.4%</p>	<p>Weak analogy; Non-actual</p> <p>Results: Valid: 5.2% Moderately valid: 20.3% Not valid at all: 74.5%</p>

Table 2: Validity ratings of analogical arguments

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