Population Gestalt:

Simple Tools to Focus Herd Problems

Dale Hancock, *DVM, PhD*
Field Disease Investigation Unit
Washington State University
Pullman, WA 99164-6610

A problem must be visualized before it can be solved, and, for populations, this requires special, pattern-recognizing tools. Temporal and risk group analyses help create a mental picture of what's going on in a population, which helps us to intelligently construct a ruleout list.

People who know native range plants don't mentally walk through the steps in a dichotomous key for each plant that they see. Tentative recognition occurs almost instantly based on the simultaneous synthesis of a few key features that become—to the neural network of the human mind—a single, identifiable whole. Even from fragmented, incomplete sensory data, whole images can be constructed intellectually and related to past experience.

Modern concepts that the perceived whole is greater than the sum of the sensed parts and that our minds actively seek organized perceptions from fragmentary data are legacies of Gestalt psychology. The formation of gestalts (*Gestalt: German for pattern or configuration*) is important in the early stages of problem solving in that it lets us classify elements of the problem, relate it to prior experience, and mentally prepare a list of alternatives (= ruleouts or hypotheses) to be further explored. For example, when we see a cow with a unilateral lacrimal discharge, our minds focus on this pattern (drainage under eye, unilaterally) and begin to prepare a list of ruleouts and strategies for getting to a diagnosis.

Unfortunately, human minds don't come innately equipped to form the gestalts we need for solving problems in populations. In his formative *The Interpretation of Ecological Data,* EC Pielou wrote: "Although natural, living communities as they are found in the field are ... an ecologist's ultimate raw material, it is impossible to come to grips with them mentally without first representing them symbolically." While Pielou's work dealt with plant communities and his specific methods are not directly applicable to our needs here, herds of cattle are nonetheless populations living in multi-species communities (of at least 100 or so species). We need to be able to "come to grips with them mentally" if we are to effectively solve herd problems. Some have claimed the ability to just walk through a cattle operation and "get a sense" of what's going on (or maybe they mean "scents"). Walking through the place is a good idea and will yield useful information, but limiting oneself to wandering around "getting a sense" will not make for effective problem solving.

The special pattern-recognizing tools we use to help us solve herd problems are called statistics. Fortunately, this does not include the pedantical statistics of complex formulas and "p-values" but the more familiar and utilitarian descriptive statistics of graphs and tables. We use descriptive statistics to help form gestalts of population problems just as we use stethoscopes, thermometers, X-rays, and ECGs as aids to our senses in forming gestalts of the problems experienced by individuals (Figure 1).

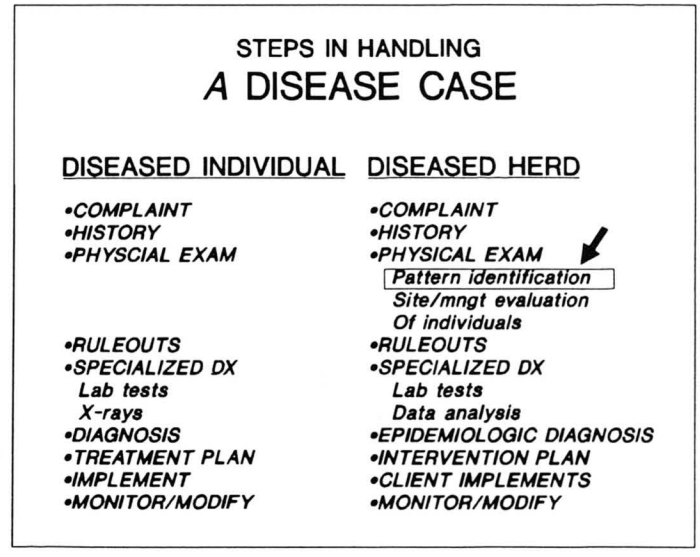

Figure 1. If we compare steps for solving disease problems in individuals to that in populations, we see that pattern identification serves a role similar to the physical exam.

Temporal analysis ("Population T.P.R.")

Temporal charts are graphical displays of the occurrence of health events or the level of productivity over time. At least 2 reasons exist for preparing temporal charts: 1) to give insights about the nature of the agent and 2) to give clues about the incident or factor which incited the problem.

As shown in Figures 1-3, the pattern of disease occurrence depends on agent characteristics and how the agent interacts with the population. "Agent" used in an epidemiologic context can denote a toxic or nutritional substance as well as an infectious organism. A non-communicable agent (eg, a toxin or a non-communicable infectious agent) to which a single exposure occurred over a short time span will give a picture similar to that in Figure 2. A communicable agent with a tightly defined incubation period will result in the prototypcial propagating disease occurrence pattern as in Figure 3. If the incubation period is poorly defined, the pattern will be more like that in Figure 4.

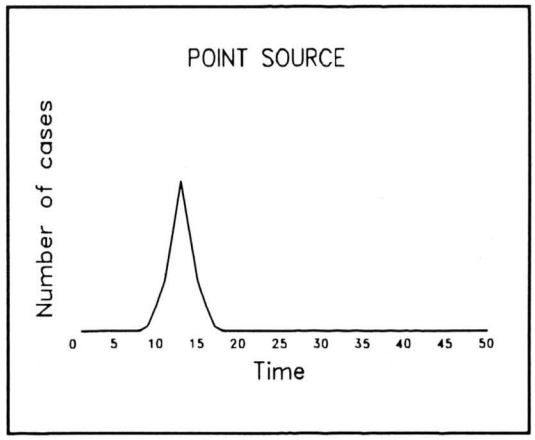

Figure 2. This pattern is typical of toxic and non-communicable infectious agents for which a single, brief exposure occurs.

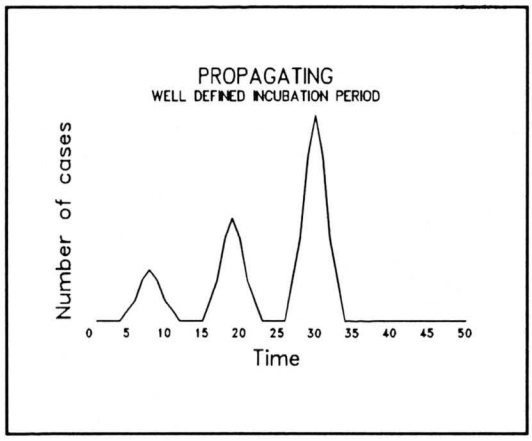

Figure 3. Propagating epidemic with incubation period of 12 days. Number of cycles is dependent on agent and population features.

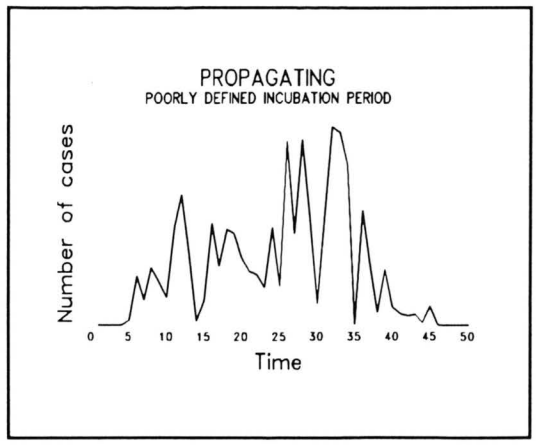

Figure 4. Due to variation in exposure dose and in host resistance, most propagating epidemics will not have the well defined waves as in Fig 2.

The simplest method for constructing a temporal chart is demonstrated Figure 5. This method will not serve in all situations, particularly where the population at risk (and thus the denominator) changes greatly from one time to the next. However, for short duration outbreaks where the population at risk is more-or-less constant in number, graphing cases on a time line is simple and effective.

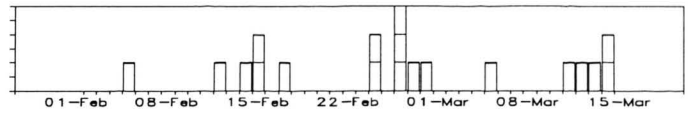

Figure 5. For many investigations an adequate temporal chart can be made simply by graphing the cases on a time line.

Table 1. Data for Temporal Chart Construction Example.

ID #	Onset Date
254	02/05/91
455	02/12/91
333	02/14/91
125	02/15.91
245	02/15/91
543	02/17/91
345	02/25/91
456	02/24/91
298	02/26/91
412	02/26/91
178	02/26/91
187	02/27/91

Consider a (fictitious) cow-calf herd with a perinatal mortality problem (Table 2). Note we can't

Table 2.

Week beginning	Total births	Perinatal mortalities	Perinatal mortality incidence
Feb 1	12	1	8.3%
Feb 8	11	7	63.6%
Feb 15	16	1	6.3%
Feb 22	22	2	9.1%
Mar 1	16	3	18.8%
Mar 8	13	3	23.1%

just graph number of cases by week since only those cows which calve are at risk of having their calves die perinatally. We need to compute perinatal mortality incidences for cows calving during each week. We can relate the incidence of perinatal mortality to other occurrences such as feed changes or, as shown in Figure 6, daily environmental temperatures.

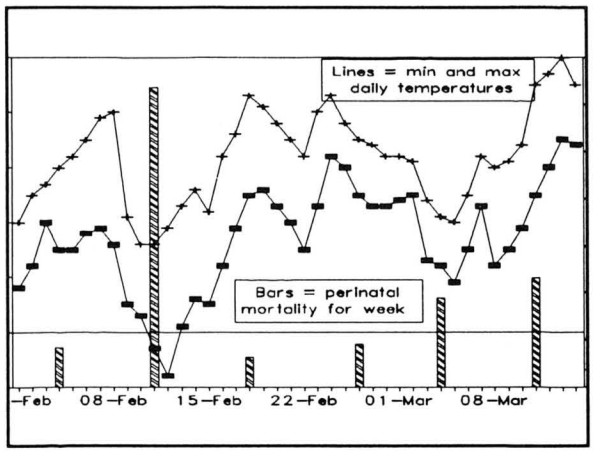

Figure 6. Temporal pattern of perinatal mortality graphed with min and max daily temperatures.

In dynamic populations, such as feedlots and calf raising operations, determining exact numbers at risk is often difficult since cattle are coming and going on a daily basis. This is true of a lactating dairy herd, as well. Where the population is relatively constant in size, one can simply graph cases against time, ignoring the denominator altogether. Alternatively, one can use, say, weekly census data provided by management and compute true rates: deaths (or cases)/1000 cattle-weeks. Whatever method is chosen, the goals are to gain insights about the nature of the agent (propagating or else) and, by juxtapositioning with other events or ongoing occurrences on the same graph, to aid in the formulation of hypotheses about inciting exposures.

Risk group analysis ("Population radiology")

Risk group analysis is comparable to the temporal analysis suggested for the perinatal mortality outbreak (Table 2 and Figure 6). We divide the population into groups and divide the number of cases (or deaths) by the numbers within the respective groups. The term "group" as used here is not limited to physical groups, but can be groups established by, say, breed or parity or any other distinguishing feature.

Table 3 shows the results of risk group analysis in the cow-calf herd experiencing a perinatal mortality outbreak (same fictitious herd as in Table 2 and Figure 6). This was done using the cross tabulation procedure of a microcomputer statistics package, though it can be done with a spreadsheet or even by hand. In each cell is displayed the counts (number of cows), and below it is displayed the column percents. For example, 85.7% of calves born to 1st calf heifers did not die perinatally while 14.3% did. It is obviously the latter figure on which we concentrate, even though the computer gives us both. Note that each cow was of a certain parity and breed, had a particular calving ease score, and birthed a calf in a certain weight range. This is typical in that we can perform a variety of risk group analyses on the same animals. It is also possible to look at two groupings at once. For example, we could compute perinatal mortality among all the parity-x-breed categories (1st parity Herefords, etc.). However, one rarely has enough data to allow for such excursions, and one is limited to simple crude risk group analysis.

Gestalt formation

The prototypical example of gestalt formation is the verbal sentence (arguably, all our higher intellectual capabilities are phylogenetically derived from language). We hear isolated words which, alone, could have a variety of meanings, but the meaning we derive is in considering all the words in the context of each other. In so doing we create an idea (a gestalt) of what the speaker is saying. We may not understand completely what the speaker is saying from just one sentence, but will—almost unconsciously—begin to formulate one or more hypotheses. We will seek to clarify which of the hypotheses is operational by listening further, or, perhaps, by asking a directed question.

So it is with any problem solving. We consider all the preliminary information at once in an effort to formulate hypotheses about what is going on. For example, in the perinatal mortality problem, we see that the risk seems to be greater in older cows, in higher milking breeds, and among calves of average birthrate. Most of the losses are among calves which experienced difficult births—which strikes us as unusual given the ages of

Table 3. Cross Tabulation of Perinatal Mortality (Perimort) By Parity.

CROSS TABULATION OF PERINATAL MORTALITY (PERIMORT) BY PARITY

PERIMORT	PARITY 1	2	3	4	5+	
0	12	16	13	10	22	73
	85.7	94.1	81.3	83.3	71.0	
1	2	1	3	2	9	17
	14.3	5.9	18.8	16.7	29.0	
	14	17	16	12	31	90

CROSS TABULATION OF PERINATAL MORTALITY (PERIMORT) BY BREED OF DAM (BRD)

PERIMORT	BRD 1	2	3	4	
0	7	38	14	14	73
	100.0	86.4	73.7	70.0	
1	0	6	5	6	17
	0.0	13.6	26.3	30.0	
	7	44	19	20	90
	7.8	48.9	21.1	22.2	100.0

BRD = breed of dam, 1=Hereford, 2=Angus, 3=Holstein-x-Herford, 4=Simmental

CROSS TABULATION OF PERINATAL MORTALITY (PERIMORT) BY CALVING EASE (CE)

PERIMORT	CE 0	1	2	
0	61	6	6	73
	91.0	46.2	60.0	
1	6	7	4	17
	9.0	53.8	40.0	
	67	13	10	90
	74.4	14.4	11.1	100.0

CE=Calving ease score, 1=no assist., 2=easy pull, 3=hard pull

CROSS TABULATION OF PERINATAL MORTALITY (PERIMORT) BY WEIGHT OF CALF (WGTCAT)

PERIMORT	WGTCAT 1	2	3	
0	30	31	12	73
	85.7	86.1	63.2	
1	5	5	7	17
	14.3	13.9	36.8	
	35	36	19	90

dams. We consider these data all at once and hypothesize: nutritional problem, perhaps mineral imbalance and hypocalcemia. We formulate a plan to test this hypothesis, and have thereby demonstrated efficient problem solving.

What about P-values? Are all the associations in Table 3 significant and shouldn't we ignore them if not? The misconception embodied in the second question is why P-values have no place in the hypothesis generation phase of herd problem solving. Would we, by analogy, discard any word from a sentence if we were not certain of its meaning in isolation? Certainly not. Would we, in the problem solving of an individual sick animal, discard tentative client observations such as polyuria just because we could not "prove" the animal was urinating significantly more "(P<.05)" than the average animal? Certainly not. Why should relationships among variables in populations be different?

The notion that findings have to be "statistically significant" to be considered is an artifact of formal experimental hypothesis testing. In a formal experiment, we already have a hypothesis; we randomize animals into groups, measure the response, plug in the data, and read the P-value, which—under these conditions—is a reliable estimate of type I error (concluding an effect where none truly exists). In herd problem solving we do not, at first, have an adequate hypothesis list—that is our goal. Even when we do have one, we have not randomized animals into groups, and, thus the P-values computed from our observational data bear no dependable relationship to type I errors (technically due to residual confounding and interaction). P-values are, therefore, not even good tools for **testing** hypothesis in most herd problem solving, unless we are using a formal intervention trial for this purpose. It is also noteworthy that, in the hypothesis testing phase of problems that actually occur in this World, our goal is not to evaluate our hypotheses one at a time using some putative "truth formula" but simply to choose among them. P-values have no utility for "choosing among" and, indeed, are regularly misleading in this regard.

Perhaps the worst legacy of formal statistics with all its supposed "truth" formulas and its de-emphasis on simple graphs and tables, is that it leads us to have expectations of data analysis which cannot be met. In reality, risk group and temporal analyses are directly comparable to other skills with which most veterinarians are familiar. In conducting a physical exam of an individual, we do not expect any single procedure to provide a rush of insight that instantly solves the problem. A particular body temperature or heart rate will be compatible with a constellation of diagnoses, and we should not expect more in the physical examination of herds. What we can always count on from temporal and risk group analyses, however, is that they will help us to formulate a list of utilitarian hypotheses. Without a utilitarian hypothesis (e.g., that management failed to provide a mineral program appropriate to available forage), problem solving becomes so much wandering in the wilderness.