changing, and that "we will not see it until we believe it" (9). But ultimately we will accept the reality and find our best personal means of serving our clients.

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# The use of computers in dairy herd health programs: A review


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## Abstract

**This review of the literature covers the changes in the approach to veterinary health management that led to the introduction of computerized herd health programs and the various other applications of the computer in the practice of dairy herd medicine. The role that production recording systems, mainframe computers, minicomputers, and microcomputers have played in the evolution of herd health programs are also reviewed.**


## Development of dairy herd health programs

Often the primary justification for the initiation of a herd health program is to help resolve a situation in which the productivity of the herd is less than what is considered optimal (1). The overall goal of a herd health program has been defined as the maintenance of animal health and production at the most efficient level that will provide maximum economic returns to the farmer (2). As well, the veterinarian should continue to implement new techniques that will result in improved efficiency (3).

An historical look at the evolution of veterinary medicine reveals that the primary focus of veterinarians at the beginning of the century was the development and implementation of control programs for the major infectious diseases of livestock (4). The role of the veterinarian in this effort was quite important. The importance of this role was based on economics and the potential impact of these diseases as zoonoses (5).

The economic growth that occurred after the second world war resulted in an increased demand from the population for food animal products. The resulting forces of supply and demand led to an increased value of the individual animal (6) making it economically feasible to call a veterinarian to examine an animal. Thus, during this time, the emphasis of veterinary medicine became that of the individual animal. There was also advancement in the skills of the veterinary clinician, and the technology that was available for use in practice. However, as this type of veterinary service was devoted to the treatment of individual animals that were identified by the farmer as being sick, practice was farmer directed (7). The only work that was being done at the herd level was in relation to the control of disease as part of government programs, such as brucellosis eradication.

Recognition of the fact that this clinically oriented provision of veterinary service was not making improvements in overall performance led to the concept of herd health (1). This concept was termed by Moller (8) as "Planned Animal Health and Production Services" (PAHAPS). The idea was to provide veterinary service on a routine, scheduled basis that involved consideration of, what the owner perceived as, the healthy animals in the herd. At the same time there was a growing awareness of disease conditions that did not manifest themselves as clinical disease, yet resulted in decreased productivity (1). These losses in productivity were associated with changes in the health and production of the population, rather than with clinically apparent disease of individual animals (9). The effects of subclinical disease, especially in the areas of mastitis and reproduction, became recognized as the most important impairment of production efficiency (10).

The early programs, which commenced in the 1960's, involved regularly scheduled visits to the herd where the focus of attention was on reproduction (11,12,13). These visits also included discussion of management procedures related to mastitis control and calf diseases. Records on the prevalence of disease conditions in Australian dairy herds during this time period revealed that between 66% ad 75% of diseases of cows involved reproduction and the udder (10,14). Similarly, Shanks *et al* (15) estimated that suboptimal reproduction and mastitis accounted for 55% of the


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total loss due to disease in dairy cows in the US. Thus, there was a logical basis for the components of these early health management efforts.

These programs promoted the need for a good record-keeping system on the farm, which essentially consisted of individual life history cards. The emphasis of these early herd health programs, although having adopted a preventive philosophy, centered on the individual animal, and provided no herd level analysis.

Morris (10) suggested that the major factor determining the acceptability of disease control programs to the dairy industry was the farmer's expected economic benefit from adopting the program. A study by Barfoot *et al* (16) examined the economic value of the type of herd health program described by Cote (11). The results indicated that the application of a herd health program was economically beneficial, and that the return on the investment was related to, and increased with, the level of adoption of the program by the farmer. Although control herds were used in the study, there was no assessment made of the equality of the herds before initiating the herd health program. Sol and Renkama (17) examined the economic benefit of a similar type of herd health program using herds that were comparable before initiating the program. This study also indicated that a herd health program of this type was a good investment.

Although the early herd health programs had been demonstrated to be of value, some authors suggested that the objective of increased profitability of the farm could not be fully realized due to the inability to identify problems at the herd level (18,19). Nevertheless, the importance of the individual cow oriented monthly herd visits has led to this type of herd health practice as a predominant form of delivery (20).

The need to be able to evaluate the status of the herd with respect to subclinical disease problems led to the concept of targets of performance (1). It was emphasized that these targets of performance must be set as herd goals, as the approach is based on assessing the herd as the unit of performance. The concepts of subclinical disease and targets of performance have led to a redefinition of disease at the herd level. Disease becomes relative to what is consider to be health, and is defined in terms of a deviation from some standard of health (21,22). Management inefficiencies are now considered a component of disease, as they have also been demonstrated to result in suboptimal performance (23). Given the objective of optimizing production efficiency, performance targets must be defined in biological terms which are related to the economic efficiency of the herd (24). However, the assumption that biological targets are equal to economic targets should not be made. Indeed, with respect to milk production there remains the question of whether maximum biological production and economical production are equivalent (25). The positive economic benefit of a herd health program based on the analysis of data at the herd level, and comparison to performance targets, has been demonstrated by Williamson (26).

The veterinary profession has been slow to develop the necessary research tools needed to identify causal factors associated with complex herd disease processes (5). Multiple determinants of disease, such as management, environment, resistance to infection and behavioral patterns are likely to be involved. Although much progress had been made in their control, production diseases still constitute a constraint on productivity.

In order to be able to evaluate the status of herd level health and performance, the computer was introduced into herd health programs. The use of computers dramatically reduced the labor required by the veterinarian and the farmer in the repetitive tasks related to data preparation and analysis (1,18,27). Today, the use of computers, or computer-derived information, has become an integral part of the herd health programs. The expansion of herd health during the 1980's to include production, management, and disease monitoring has resulted in an integrated approach to food animal practice (23). This type of herd health practice is now often referred to as "production medicine". Monitoring at the herd level, which is the continual assessment of deviations of actual herd performance from targets of performance, using computer-derived information, is now considered to form the basis of herd health practice (28).

## Production recording systems

The first use of computers as a management tool in dairy farming was by the milk recording services starting in the 1950's in the United States (29). Collectively, these organizations became known as the Dairy Herd Improvement Association (DHIA). In Canada, the Record of Performance (ROP) program, operated by Agriculture Canada, served the needs of the purebred dairy industry. The development of Dairy Herd Improvement (DHI) programs in several provinces provided a similar service to commercial dairy herds. It was during the 1960's that computers were first used by the DHI programs in Canada (30). In Canada at the present time the two largest milk recording services are the Ontario Dairy Herd Improvement Corporation (ODHIC), which serves Ontario, and the Dairy Herd Analysis Service (DHAS), which provides service to Quebec, Saskatchewan, and the Maritime provinces. The remaining provinces continue to use the Federal ROP program or smaller provincial DHI services.

With the advent of official milk recording and computerized records, DHI programs promoted the need for, and use of unique individual animal identification. The records that were produced were intended to provide information to farmers on individual cow production. From this information, decisions could be made about feeding, management and culling (29). The official milk records collected by DHI associations are maintained in large centralized mainframe computers. These databases also provide the information needed by the artificial insemination industry to develop sire proofs and aid in genetic selection programs. The use of milk recording services by farmers has resulted in large advances being made in production and in the genetic potential of the dairy cow. This has resulted from the use of DHI information as a management aid to dairy producers and in providing a large research database to develop new techniques (30).

Currenty, in Ontario, approximately 70% of all milk producers in the province use the services of ODHIC (31). Growth in the use of DHI programs occurred throughout North America and resulted in an expansion of the services they provided (32). Most DHI programs now offer, in addition to individual cow production records, somatic cell count (SCC) data, reproductive performance parameters, nutrition information, and management worklists. This information can be summarized and reported at the herd level through the use of computers. In Canada, this type of report is being provided by the DHAS program, whereas in Ontario, ODHIC does not yet report reproductive or nutritional information (31).

Dairy herd improvement programs do not collect and report on the health aspects of dairy cows. However, their ability to provide current and projected production data at both the individual and herd level has made the use of DHI records an integral part of providing a herd health program (33). The use of DHI records as part of a herd program has been described as the equivalent of performing a physical exam on an individual animal (34). Examination of the herd through information contained in the DHI reports, in the areas of mastitis control and reproductive management, have been described by several authors (35,36,37). As well, Fetrow *et al* (28) consider this information to be an important source of data for dairy herd monitoring.

The attitude of producers toward the use of DHI records is important in relation to the implementation of a herd health program (38). In this regard, Smith and Schmidt (39) assessed the attitudes of Ohio dairy farmers towards the use of DHI services and the relationship to herd performance. It was reported that producers who felt DHI services were worth the cost, had a greater increase in production than those who did not feel DHI programs were worth the price. Schmidt and Smith (40) also reported that the primary reason indicated by farmers for being enrolled on DHI was to have monthly progress reports on performance. The second reason was to enable producers to feed cows according to production.

In ranking the relative usefulness of the DHI reports, most farmers found the individual cow information more important than the herd summary information. However, they rated the ability to compare herd performance with goals as the next most important.

## Mainframe computer systems

Although the DHI programs were the first source of computer-generated information for dairy farmers and their veterinarians, they initially only provided reports of production. During the 1970's, several computer-based data handling systems were developed that essentially dealt with reproductive performance. These systems were intended to supplement production information received from the DHI program (41,42,43). At the same time, programs designed to monitor both the health and reproduction of dairy herds were being developed (18,44). All of these programs entailed collection of data that had been recorded on-farm, entry of this data into a mainframe computer system, and generation of herd analysis reports, which were then returned to the farmer and his veterinarian. None of these programs became widely implemented on a practical basis.

The need for a workable system to provide herd level analysis of all aspects of Australian commercial dairy operations, and the ability to compare to herd targets, led to the development of a data collection and analysis system (1). This system, operated through the central computer at Melbourne University, was developed over a ten year period. It began as an inefficient manual records and analysis service, that led to the use of on-farm diaries and computer-generated monthly analysis reports (45). Enhancements made to the program have been described by Williamson *et al* (46).

Through a cooperative effort with the University of Melbourne, the MELBREAD herd health and fertility reporting scheme was developed by the Veterinary Epidemiology and Economics Research Unit (VEERU), University of Reading, in 1971 (47). Over several years, its use resulted in extensive redevelopment into a more integrated system that incorporated milk yields, and was known as the DANDAIR program. Operational difficulties resulting from use of the system on a mainframe computer necessitated transferring the program to a minicomputer system in 1979. The latter system became known as DAISY (48). The use of the system on a minicomputer greatly aided the turn-around time of reports compared to using the central mainframe computer, which relied on the mail service (49). The program was implemented and operated on five minicomputers located at different sites and was utilized successfully to serve about 250 dairy operations (50,51).

Other mainframe-based programs, capable of creating herd management action lists and herd analysis reports, were developed. These include programs described as VIRUS (52) and COSREEL (53). The COSREEL program differed from others in that it utilized a remote terminal and telephone lines for both data input and output. This was done to improve information transfer, but was limited by the technology of the time with respect to speed of data transmission (53). Neither of these two programs were developed and utilized to the extent of either the Melbourne system or the DAISY program. It was emphasized by Cannon *et al* (45) and Erb *et al* (42) that data recording and input must be simple and convenient for both the farmer and the veterinarian. In order to facilitate these functions, the use of codes was developed (45). All of the programs previously described utilized codes to facilitate data entry and storage. However, the programs translated the information back into a text format for simplified interpretation and acceptance by farmers (52). The use of a coding scheme has been described as a limitation of such programs, as they were restrictive and became difficult to adapt to the creation of new events (48). The coding method described by Russell and Rowlands (53) for COSREEL was developed to allow for more flexibility by making use of alphanumerics. The usefulness of the program in a field setting has been described by Rowlands *et al* (54).

The FAHRMX (Food Animal Health and Resource

Management System) computer system was created at the University of Michigan. The objective of this system was to develop a dairy herd monitoring program to provide a research database and to serve as a health management tool (55). This system differed from those programs already in existence, in that it made use of the new technology of stand-alone microcomputers placed in local veterinary practices for data input and printing of weekly management worklists. The herd data were transferred by disk to the mainframe computer, where the data analysis was performed and the monthly herd analysis reports generated. The system also made use of electronic transfer of milk data from DHI to the FAHRMX mainframe computer. The system grew from an initial 12 herds to a total of 31 dairies. The ability of the program to produce useful information on numerous herds for research purposes and as a herd health management tool has been demonstrated (56–59). In common with the other mainframe-based programs, it relied on a coding system for entry of events and was dependent on the mail service to provide the monthly analysis reports to producers. Similar problems of delayed turn-around time resulted.

These initial computer-based herd health programs allowed for the collection and processing of health as well as production data. Various methods have been described for obtaining farm level information. However, they all required the functions of a centrally located computer for the analysis of the data. In essence, they were all operated from a remote centralized facility, with their main limitation being the distance of the computer from the source of the data.

## Microcomputer systems

The rapid development of microcomputer technology in recent years has led to the introduction of dairy herd management software programs that were no longer dependent on centrally located mainframe computers. Microcomputers increased the efficiency and timeliness of the information that was produced (60,61). The need to develop herd monitoring programs, that could be used on the various types of stand-alone microcomputers, necessitated that software be written in a transportable computer language (48). Recognizing this need, Stephens *et al* (62) created a microcomputer version of DAISY that allowed it to be used as either an on-farm system or as a bureau system operated from a veterinary practice.

Since the early 1980's there have been numerous microcomputer programs developed for use in dairy herd management. Essentially, all such programs provide the capability of producing management worklists and herd level analysis reports. A standardized assessment of several of the microcomputer programs available at the time was conducted by Etherington *et al* (63). This study involved entry of a standard set of herd data and evaluation of each program on its ease of input, format of output and accuracy of analysis. The overall conclusion reached from the study was that no one product stood out in all of the areas that were evaluated. It was recommended that these types of software programs needed to be implemented in a field setting to further evaluate their usefulness.

As a follow-up study by the same researchers, Menzies *et al* (64) implemented the Dairy Herd Management System (DHMS) as both an on-farm and bureau system. In the on-farm setting the producer was responsible for all aspects of data manipulation, whereas the bureau system involved collection of the data from the farm with input and analysis performed at the veterinary clinic. Reports on the use and usefulness of the DHMS program indicate that it performed well and that the information was well received by producers in both settings (65,66). The main disadvantages in the use of the program were its limited capability for data manipulation outside of predetermined reports and the inability to electronically transfer data to and from other computers. Menzies *et al* (66) indicated that in Ontario, the relatively small herd sizes meant farmers were reluctant to purchase such a system for on-farm use. It was suggested that operation as a bureau service from a veterinary practice warranted further investigation.

A commercial software system called The Dairy Herd Management Program (DHMP) has been reviewed by Lehenbauer (67) and was found to be a useful tool when implemented as part of a dairy herd health program (61). An advantage of this program over the DHMS program would appear to be the ability to input herd target levels. However, it too was found to be limited in its flexibility in the format of reports that are created. As with most of the currently available dairy herd management software, it is under revision to provide further enhancements.

The usefulness of the program known as Dairy Comp 305 was reviewed by Goodger (68). This dairy software package has been used extensively as an on-farm system in California dairies. It differs from the previously described systems, in that it is extremely flexible with respect to its potential for data manipulation and reporting. In fact Dairy Comp 305 is so flexible that it provides few standard reports, leaving definition of output format to user-defined needs. According to Goodger (68) the main limitation of the program was that information is mainly limited to the current status of the herd. Data must be transferred, by use of ASCII files, to an outside program or computer to be able to assess long-term trends. The University of California School of Veterinary Medicine uses a minicomputer to keep a database of the information created on-farm allowing for multi-herd analysis for research purposes.

The use of a program that was developed in the Netherlands, called Veterinary Automated Management and Production Control Program (VAMPP), has been described by Noordhuizen *et al* (69) and is similar in its capabilities to the programs already described.

Other dairy herd management software programs are currently available for use on microcomputers. However, since these programs have not been described in the literature, no comments can be made as to their use (i.e. application) or usefulness (i.e. utility) as part of a herd health program. Overall, it would appear that most programs have been developed for use as dairy herd management packages and are useful.

However, all such systems described would appear to have limitations in their integration with veterinary directed herd health programs as they were not designed for that purpose.

## Current developments in the use of computers in herd health

The major limitation of every computer system, no matter how sophisticated, is that the hardware system utilized is no better than the software program with which it functions (70). Elmore (71) stated that no one currently available microcomputer system completely meets the requirements for optimal computerization of reproduction and production records. This statement supports the findings of Etherington *et al* (63) in their assessment of available software.

Although the amount of information provided through DHI centers has increased, DHI programs have also not totally met the needs of dairy practitioners. These deficiencies have led to the development of new herd monitoring tools (72,73). Fetrow *et al* (73) have described a system which utilizes a commercial spreadsheet program to monitor information available from the DHI report and health data that are recorded separately by the farmer. The program incorporates the concept of herd targets of performance and can display herd trends graphically. This system does not attempt to store or evaluate information at the level of the individual cow.

Technological advances have resulted in the practical applications of electronic data transfer. This has allowed producers to access their information stored in the DHI database and download it to on-farm microcomputers (36). One such system, known as DART (direct access to records by telephone), is available in some parts of the US. It has allowed the producer and the veterinarian, as part of an integrated herd health program, to transmit and receive data from the central database via an on-farm microcomputer and a modem. The DART system makes use of the storage capacity of large mainframe computers, yet accommodates the immediacy of access to the information as required by producers for day-to-day management activities or the veterinarian as part of a herd monitoring program (73). Incorporated with a microcomputer program to monitor the health aspects of the herd, this type of system has the potential to become a truly integrated herd monitoring scheme. The on-line use of DHI information has been promoted as necessary in order to prevent the independent use of on-farm microcomputers from eroding the national database that has been established over many years (74).

A hierarchical system for information management has been proposed by Etherington *et al* (63), and supported by Menzies *et al* (66). This hierarchy would have microcomputers processing farm data as its foundation. Dohoo (75) has outlined the objectives of the Animal Productivity and Health Information Network (APHIN) which embodies this philosophy. This network is being implemented at the Atlantic Veterinary College, Charlottetown, PEI, Canada. Microcomputers are used to process on-farm data and are linked electronically to the central computer which allows for incorporation of data from other sources, such as DHI services or diagnostic laboratories, into one large database. The network would allow for independent use of the information at the farm level, while also creating a provincial herd monitoring system. At this level, information can be used to make assessments of the economics of differing types of herd programs and identify priority areas for future research.

The need still exists for research into the implementation and development of computerized record-keeping systems for on-farm data collection (76). Such systems must be simple to use, provide accurate data for analysis and generate useful information. There is also a need to assess their use and usefulness with respect to the needs of the dairy farmer, the veterinarian, and potentially higher level agencies.

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