Veterinary Biologic and Therapeutic Agents in Virginia Sheep Production

by

Rebecca Kathleen Rorrer

Thesis submitted to the Faculty of the Virginia Polytechnic Institute and University in partial fulfillment of the requirements for the degree of

Master of Science
in
Veterinary Medical Science

Approval Committee

Chair: Kevin D. Pelzer, DVM, MPVM
François Elvinger, Dr. med. vet., PhD
Scott Greiner, PhD

August 16, 2002

Blacksburg, Va

Keywords: pharmaceuticals, sheep, survey

Veterinary Biologic and Therapeutic Agents in Virginia Sheep Production

By

Katie Rorrer

Committee Chair: Kevin D. Pelzer, DVM, MPVM

Veterinary Medical Sciences

(ABSTRACT)

Biological and therapeutic agents are used in food animal production to maintain animal health and well being, prevent and treat disease, and to maintain or enhance production. Concerns about the use of pharmaceutical agents in food animal production have been raised, especially in relation to food quality and safety. This study addressed the scarcity of information concerning the quantity of pharmaceuticals being used and the reasons for their use in sheep production. Additional goals included determining the sources of information used by shepherds in making treatment decisions and evaluating the economic impact that pharmaceutical usage has on sheep production. Thirty-nine Virginia sheep producers participated in this study of four months duration from March through September. After completing an initial questionnaire to determine flock and management characteristics, participants were asked to record all treatments with biological and therapeutic agents that occurred within their sheep flocks. A total of 14,310 treatments were recorded for a median of 1.5 treatments per sheep per month. Parasite control and vaccination were the most frequent reasons for treatment (64.9% and 15.2%, respectively) with vitamin/mineral supplementation being the next most common (8.8%). Price information was collected for 13,912 treatment events. An estimated total of $7,523.78 was spent on pharmaceutical treatment over the course of the study. This amounts to a cost of $0.63 per sheep per month of observation. Results of this study will enhance the ability of producers to evaluate treatment decisions, allow comparisons to be made between operations and provide a base of information for future research.

Acknowledgements

Funding for this study was provided by *Trimpi Grant Funds*.

I would like to thank my committee members for their guidance and support over the past two years. Specifically, *Dr. Scott Greiner* for helping me locate producers to take part in the study and for giving me the opportunity to present the preliminary results of the study at the 2002 Virginia-North Carolina Shepherds Symposium; *Dr. François Elvinger* for the time spent reviewing stats and tables; *Dr. Kevin Pelzer* for the long hours reading and re-reading the multiple drafts of this thesis.

A special thanks to *Dr. Melinda Mulesky*, my supervisor at CropTech for allowing me to have a flexible work schedule and helping me at the lab so I could take days off as needed to complete this study.

Most importantly, this project could not have taken place without the willingness and cooperation of the 39 participating sheep producers. Their time and effort is truly what made this project work.

Table of Contents

List of Tables

List of Figures

Introduction

Pharmaceutical and biological agents are used in animal production to maintain animal health and well being, treat and prevent disease and to enhance production. Concerns have been raised over the use of pharmaceuticals in food animal production, especially in regards to food quality and safety. The beef, dairy, and pork industries have developed quality assurance programs to decrease the occurrence of drug and chemical residues and to increase the quality of meat and milk that are produced[1-3]. Because there are few drugs labeled for use in sheep, producers may choose to use products in an extra-label manner. Depending on the source of information the producer uses for making treatment decisions, the use and administration of drugs may not be in accordance with FDA guidelines, which may increase the chance for residues in meat and milk. Information on the frequency of drug usage and the types of drugs used to treat different conditions must be collected before a quality assurance program can be implemented in the sheep industry.

The specific objectives of this research project were to determine

1. what products are being used by Virginia sheep producers.
2. how the producers are administering products.
3. what conditions producers are treating.
4. the sources of information used by sheep producers in making treatment decisions.
5. the source of medications used in treatments.
6. the cost of treatment per sheep per month.

Information collected in this study will enable veterinarians and extension personnel to develop training programs for those utilizing pharmaceuticals in the sheep industry.

Review of Related Literature

I. Drug Approval and Legislation

There are currently over 1400 drugs approved for veterinary use by the United States Food and Drug Administration (FDA), but only 21 pharmaceutical agents have been labeled for use in sheep (Appendix 1). The lack of approved products can make it difficult for veterinarians and producers to provide for the health of sheep flocks while at the same time assuring that food products derived from sheep are safe and wholesome.

In order for a pharmaceutical product to be approved by the FDA, the drug sponsor must conduct studies demonstrating that the product is safe and effective, can be uniformly manufactured and that food products derived from treated animals are free from the drug and its metabolites are safe for human consumption[4-6]. Information must be provided on residues that may be found in food from treated animals, how the residues may affect humans, how residue occurrence can be reduced, and what types of residue monitoring should be performed if the drug is approved for use. Additionally, the sponsor is responsible for developing testing procedures to detect the drug or its metabolites[7]. The FDA uses this information to set an allowable level of the drug residue in the food, called the tolerance or Maximum Residue Level (MRL)[6,8]. The MRL is defined as the maximum concentration of a substance that is allowed in animal tissue and is set using data that defines a "no-observable-effect-level" (NOEL) for the compound. The NOEL is the highest concentration of a drug that produces no toxic effect and is used to determine the acceptable daily intake (ADI) of a substance. The Maximum Residue Level is designed to keep drug residues below the ADI[8,9]. The withdrawal time, the time it takes for a drug concentration to decrease below the MRL is also set for each drug. Withdrawal times are influenced by dose, form of the drug, route of administration, pharmacokinetics of the drug and the health status of the animal[7,10].

Recent legislation has attempted to provide veterinarians with more options for treating animal disease. The enactment of the Animal Drug Availability Act in 1996 allowed the approval of a range of doses (instead of just one optimal dose), as long as no illegal residues resulted from the dosage administered. Additionally, field investigations

to prove efficacy were no longer required for all species that the drug was to be labeled for[11].

The Animal Drug Use Clarification Act (AMDUCA) of 1994 made it legal for veterinarians to use drugs in an extra-label manner when, based on their professional judgment, it was necessary[8,12]. AMDUCA is an amendment to the Federal Food, Drug and Cosmetic Act that regulates the responsible use of drugs in an extra-label fashion[13]. Extra-label drug use is defined as any use of a drug in a way that is not indicated on the drug label. This includes using the drug in species not listed on the label, for reasons not listed on the label, at dosages not listed on the label, using routes of administration different than listed on the label and using withdrawal times different than listed on the label[12,13]. Under AMDUCA, extra-label use of a drug is legal when an animal's well being is in jeopardy and there is no approved, effective drug available for the treatment of the animal. Additionally, extra label use must result in no violative residues and must be by or under the supervision of a veterinarian within a valid veterinary-client-patient relationship[12-14]. A valid veterinary-client-patient relationship exists when a veterinarian is familiar with the animal, is responsible for treatment of the animal and is available for follow-up consultations. Additionally, the owner of the animal has agreed to follow the instructions provided by the veterinarian[15]. The provisions under AMDUCA apply only to drugs that have been approved for use by the FDA. Additionally, it is illegal to use certain drugs, such as clenbuterol and DES, to treat food animals[13,14].

Although AMDUCA allows veterinarians to use some drugs in an extra-label fashion, there are concerns that violative drug residues could occur from extra-label use due to the lack of information concerning appropriate dosages, routes of administration, and withdrawal times. The treatment of minor species (defined as any species other than cattle, swine, chickens, turkeys, horses, dogs and cats[11]) or minor conditions (rare diseases or diseases that occur in limited locations[11]) may require the use of drugs not approved for use in animals or the administration of drugs in animal feeds. Additionally, many minor species are treated by non-veterinarians such as zoologists. Any of these circumstances make it illegal for extra-label drug use to occur under AMDUCA. Despite the need for products labeled to treat minor species or minor conditions, the small market for these products makes it economically unfeasible for pharmaceutical companies to

invest in their development[16]. The Minor Use and Minor Species Animal Health Act of 2001 (MUMS) was designed to provide labeled drugs for the treatment of minor species and minor conditions in major species. This act allows the FDA to be more flexible in the approval of products for minor species or minor uses while at the same time providing incentives, in the form of grants and tax credits, for the development of products to treat minor species and conditions[16,17].

II. Residue Monitoring

Drug residues can occur in animal tissue, milk or other products after an animal is treated with a compound. Residues can include the drug itself, its metabolites and any other substances that result from introduction of the drug into or onto the animal[8,18].

The United States Department of Agriculture (USDA) Food Safety Inspection Service (FSIS) is responsible for monitoring residues in animal tissue[7] and ensuring that any residues found in food products are below the established tolerance level. The USDA/FSIS tests for a large number of compounds including both approved and unapproved drugs [8]. The National Residue Program (NRP) prevents marketing of residue-contaminated animals through monitoring and surveillance of animal tissue[7]. The purpose of monitoring is not to estimate the total number of residue violations, but rather to determine what residues are common to what animal groups. Tissue samples are randomly selected from healthy carcasses that have passed inspection to detect, with a 95% probability, at least one residue violation if one percent of the sampled population contains violations[8]. Monitoring serves to identify residue trends as well as problem areas where additional education may be needed[19]. Surveillance focuses on testing populations that are suspected of having violative residues based on premortem clinical signs, herd history or previous residue violations[7].

III. Potential Impact of Residues in the Food Supply

Public health impacts of exposure to violative residues can be divided into acute effects and long-term effects. Acute effects occur shortly after exposure to one dose of a substance and may include hypersensitivity reactions, toxic reactions and teratogenesis[7,20]. Hypersensitivity reactions are allergic reactions in sensitized individuals

that are caused by contact with a drug. Symptoms can include rashes and anaphylactic reactions and are most commonly associated with antibiotics such as β-lactams, aminoglycosides and sulfonamides [7]. Hypersensitivity reactions are generally not dose-related and may be caused by very small quantities of the substance [21]. Four cases of allergenic reactions were reported in the literature from 1958 to 1969. These resulted from the ingestion of penicillin residues in milk. Additionally, reports of three allergic reactions due to penicillin residues in meat were reported from 1972 to 1980[22]. Although few cases of hypersensitivity reactions resulting from residue exposure have been documented[21], these reactions may be masked by other problems or may not be severe enough for the affected person to seek medical attention, so it is possible that the number of reactions is underreported [7,20].

In addition to hypersensitivity reactions, some drug residues may be toxic and cause illness when ingested. β-agonists are pharmaceuticals used to treat bronchi-pulmonary problems in both people and animals. Toxic effects from these compounds can include muscle tremors, fever, nausea, vomiting and heart palpitations. Clenbuterol is an example of a β-agonist whose residues have been implicated in several cases of food-borne illness in Europe [7]. In 1990, 135 people in Spain became ill after ingesting meat with clenbuterol residues. Other occurrences of illness associated from ingestion of clenbuterol residues have been reported in France and Spain in 1994 and in Italy in 1990 and 1995 [6]. Another example of a toxic reaction is aplastic anemia resulting from non-dose-dependent exposure to chloramphenicol[21,22]. Because of the risks associated with toxicity, certain substances, including clenbuterol and chloramphenicol, are prohibited from use in food animals in the United States.

Teratogenic compounds are ones that, when presented to fetal cells, are able to alter the structure and function of developing cells [7]. These substances can cause birth defects even at very low doses when a fetus is exposed during certain developmental periods [6].

Long-term effects of residue exposure include carcinogenesis and development of antibiotic resistant strains of bacteria[7]. A National Research Council committee reviewed literature from 1966 through 1994 and found no studies linking cases of cancer to

carcinogens found as drug residues in food[22]. It is thought that most residues occur at such low concentrations that carcinogenesis is an unlikely occurrence[7].

The National Research Council formed a committee in response to consumers' food safety concerns. This committee examined the benefits and risks of drug use in animals, focusing on the implications on human health, animal health and production economics. The committee determined that drugs and residues in the food supply were not a significant risk to human health as long as labeling directions provided with drugs were followed. Due to the increase in concern and the possible ramifications of antibiotic resistance, the committee focused on this as the primary issue associated with drug usage in animals[22]. The management factors that influence the development of antibiotic resistant organisms are not clearly understood. Microorganisms can be transferred from animals to humans through the consumption of undercooked or contaminated animal products as well as cross-contamination of non-animal products. If an antibiotic resistant microbe causes a disease in humans, specific antibiotics will no longer be effective in the treatment of the disease. A Centers for Disease Control and Prevention (CDC) investigation found that food animals were the source of resistant strains of *Salmonella* in 47% of human cases from 1971 to 1983[23]. A separate study examined the transfer of tetracycline resistant bacteria on farms where poultry were fed subtherapeutic doses of tetracycline. Within 5 months, the number of tetracycline resistant bacteria in the intestinal microflora of families living on the farm was ten-fold greater than that of neighboring families who had no contact with the treated poultry[5,23]. Often, antibiotics are used at subtherapeutic doses in feed to improve animal health and growth. This is a concern because it may allow for selection of antibiotic resistant bacteria in the intestinal track, which can then be excreted in the feces and be transferred to humans[5]. A 1987 study reported that 45% of the antibiotics used in the United States were used as feed additives[24]. It has been estimated that 80% of poultry, 75% of swine, 75% of dairy cows and 60% of feedlot cattle have been fed antibiotics at some point during their lives[23].

A second concern related to exposure to antibiotic residues is that the residues may alter the intestinal microflora; this microflora aids in the digestion and absorption of nutrients and plays a role in metabolizing drugs, synthesizing vitamins [7] and maintaining health by protecting the intestine from colonization by pathogenic bacteria [10]. It has been

suggested that alteration of the intestinal microflora might make a person more susceptible to pathogens and alter the metabolism of drugs and other substances [10]. Despite the fact that effects have not been well documented, some believe that small doses of antibiotics present as residues in food can alter the physiology of GI microflora. However, the Food and Drug Administration Center for Veterinary Medicine (CVM) has stated that exposure to antimicrobial residues in food is infrequent enough and occurs at such low doses that residues are unlikely to affect the microflora [7].

While many agree that the occurrence of these effects is possible, it is difficult to determine the number of illnesses or detrimental outcomes associated with drug residues. In order for an illness to be linked to a residue it must first be severe enough for the affected person to seek medical attention. Next, the physician must consider drug residues as a cause. This can be difficult because of the wide range of possible causes and the sometimes lengthy time between ingestion of the contaminated product and symptoms in the person. For a definite link to be made the ingested product must be tested and the results reported [7]. Due to the difficulty in establishing a direct link between illness and exposure to a drug residue, some believe that the number of residue-associated illnesses are both under diagnosed and underreported [7,20].

IV. Residue Occurrence

Residue violations investigated by the FDA from 1983 to 1988 were analyzed[25]. Antibiotics produced the most frequent violative residues and injections were more likely to result in violative residues than other routes of administration. Most of the drugs in violation were bought from a feed store or a veterinarian, and most were administered by the owner of the animal. The two most common reasons for illegal residues were failure to observe the withdrawal time of the product and failure to maintain adequate records. The analysis found that using non-approved drugs was not a primary cause of violative residues. Even when everything was done correctly some residues still occurred due to variability between animals and other uncontrollable factors, such as liver disease, that can alter the metabolism of certain drugs [25]. In a summary of on-farm follow-ups of 20% of the residue violations found by the National Residue Program in 1990, it was found that the most common cause of violations was failure to follow the withdrawal time. The

most common drug residue violations were antibiotics, with penicillin and streptomycin being the most frequent. The majority of drugs resulting in violations were bought from a feed store or veterinarian and 65% of the violations occurred from drugs administered by the owner. The number of residue violations detected by the NRP has been decreasing in recent years[26].

V. Quality Assurance

Recent studies indicate that consumers are becoming increasingly concerned about their health, especially in how it is affected by the quality and safety of the foods they consume [9]. Additionally, consumers are concerned about what drugs are being used to treat animals, how these drugs are being used, and the possibility of drug residues resulting from pharmaceutical usage. In a 1992 survey, 72% of respondents viewed drug residues as "something of a hazard". Chemical residues in food were thought of as more of a health hazard than cholesterol or saturated fat [7].

In response to increased consumer demand for safe food products, the beef, dairy and pork industries have developed quality assurance programs that focus on farm-based efforts to prevent the shipment of residue-contaminated products from the farm. The basis of the Dairy Quality Assurance Program (DQA), established in 1988, is the understanding that good herd management can reduce disease and therefore reduce drug usage. This program stresses the need for a valid veterinary-client-patient relationship, record keeping and preventive steps such as cowside residue screening [1]. The Beef Quality Assurance Program (BQAP), started by the National Cattlemen's Association (NCA) in 1985 is similar to the DQA in that it emphasizes good management practices and education of farm employees [3]. The Pork Quality Assurance Program (PQAP) was started in 1989 and emphasizes good management practices and producer education on topics such as food safety, drug administration, withdrawal times and on-farm testing [2]. This program has developed a list of areas where residue occurrence can be reduced. These areas include establishing a herd health management plan and a valid veterinary – client-patient relationship, correctly storing drugs, using appropriate drugs, maintaining adequate records and educating farm employees [2].

The USDA and FDA encourage participation in industry quality control programs [19]. Additionally, in 1993 the FDA published a series of Compliance Policy Guidelines. One of these, Proper Drug Use and Residue Avoidance by Non-Veterinarians, listed responsibilities of producers when using health care products in animals. These included recommendations such as:

- maintain records that identify animals that have been treated, the date of treatment, what products were administered, quantity given, whom administered by, and withdrawal time of the drug
- properly label, store and account for all products
- obtain and use prescription drugs only through a veterinarian within a valid veterinary-client-patient relationship
- properly educate anyone who comes in contact with animals [8]

Programs and guidelines such as these strive to reassure the public that animal drugs are being monitored and administered correctly [1]. All of these quality assurance programs focus on improving education and management practices so that fewer drugs will be administered to food animals. Before a similar quality assurance program can be started in the sheep industry, information needs to be gathered on current management practices and pharmaceutical usage in sheep production.

VI. Animal Health and Treatment

Information that has been gathered regarding management and pharmaceutical practices in the sheep industry has focused primarily on common health conditions and management practices. No information has been collected on the use of pharmaceuticals in sheep production.

The 1996 National Animal Health Monitoring System (NAHMS) Sheep survey report was conducted to identify factors that have the most influence on the health and production of sheep flocks within the United States. This survey found that books and magazines, other producers and veterinarians are the most frequent sources of information used by sheep producers. The most common conditions seen on farms from 1991 to 1996 included intestinal parasites, mastitis, foot rot and white muscle disease. Likewise, producers considered these conditions to have the most potential to affect both

their flock and consumers of sheep products. It was found that clostridial diseases, soremouth and foot rot were the most common diseases vaccinated for. Ivermectin, levamisol and valbazen were the most frequently administered dewormers. Fenbendazole, which is not approved for use in sheep, was administered by 30.3% of producers. Deworming products used to treat breeding stock are rotated more frequently than once a year by 30.9% of surveyed producers, while 32.4% report that dewormers are not rotated at all[27].

A 1998 survey of 190 veterinarians and 113 sheep and goat producers attempted to determine the health problems that are most commonly seen in sheep and goats and to determine the drugs that are most needed for sheep and goat production in the United States. The majority of the veterinarians and producers surveyed thought that there were not enough drugs approved for use in sheep and goats. They attributed this to the fact that the small market of sheep and goat products does not justify the pharmaceutical industries' expenditures necessary for the approval of such products. Both of the surveyed groups thought that antibiotics were the most needed product. Others included anthelmintics, anti-inflammatories, coccidiostats, biologics and insecticides. The most important diseases to those questioned were parasites and pneumonia. Others included mastitis, coccidiosis, foot rot, dystocia, pregnancy toxemia and vitamin E and selenium deficiency. Of those surveyed, 41% thought that veterinary services were highly valuable, 43% moderately valuable and 16% of low value[28].

VII. Economics of Animal Treatment

In addition to potential impacts on food safety and public health, the use of pharmaceuticals and biologics can impact the profitability of animal production. A 1988 study was conducted to determine the costs associated with treating and preventing disease in Tennessee cow-calf operations. Monthly site visits were made to collect information on disease incidence, drug inventory and costs of purchased drugs and veterinary services. A cost of $1.30 per cow per year was spent on veterinary services. Drugs used to treat diseases cost approximately $0.76 per cow per year and drugs used to prevent disease amounted to $10.87 per cow per year[29]. No similar information has been collected within the sheep industry.

Materials and Methods

I. Study Enrollment

A list of producers in the state of Virginia was obtained from registration lists of past sheep producer conferences in the state, involvement in the wool pool and membership in the Virginia Sheep Producers Association. An introductory letter, brief questionnaire and stamped envelope addressed to the investigator were sent to a total of 274 producers (Appendix 2). The introductory letter explained the goals of the study, the scope of participation, and requested volunteers. The questionnaire asked for information about breed, flock size and lambing time. Producers were asked to return the questionnaires regardless of their interest in participating in the study. Reminder cards requesting that producers return the questionnaire were sent one month after the initial mailing to increase return rate. Producers interested in participating were contacted by phone to schedule a time for an interview to determine flock characteristics and management practices. Producers were grouped by geographic location to determine whether the scheduled interview would occur in person or over the telephone. Of the 64 producers interested in participating in the study, 28 were interviewed in person, 30 by telephone, and 6 could not be contacted. In person interviews took place between March 3 and April 5, 2001. Phone interviews took place between March 7 and May 15, 2001. During the interviews, producers were asked 27 questions to determine producer and flock characteristics, medication usage within the flock, veterinary input in diagnosis and treatment and information on disease and disease prevention within the flock (Appendix 3). A drug inventory was made during on-site visits. Drug name, expiration date, directions and veterinary information listed on the product were recorded.

At the time of the interview, treatment cards and instruction sheets (Appendix 4) were reviewed with the participant and either left with the producer at that time (for those interviewed in person) or mailed the following day (for those interviewed over the phone). Treatment cards requested information about the animal identification number, date of treatment, name of product, amount of product used, how the product was administered, whether the product was given by a veterinarian or the producer and the reason the product was administered. Participants were asked to record all treatments,

both preventive and curative, administered to animals in their flock over a four-month period. New cards were mailed to participants every 2 to 3 weeks, along with a self-addressed stamped envelope for returning completed cards. Producers were contacted by telephone when no cards had been received for two consecutive mailings. A letter thanking participants for their participation and informing them of the last date to record treatments was mailed with the last set of treatment cards.

II. Definitions

Definitions of extra-label drug use and a valid veterinary-client-patient relationship were based on those provided by the American Veterinary Medical Association (AVMA)[30]. For the purposes of this study, the following definitions were used:

- extra-label drug use: use of a drug in a species not listed on the product label, for a disease condition not listed on the product label, at a dosage different than listed on the product label, or by a different route of administration than listed on the product label.
- product: specific pharmaceutical or biologic, ex. penicillin, ivermectin drench.
- product type: categories of pharmaceuticals and biologics, as provided by the 4th edition of the Compendium of Veterinary Products[31], ex. antibiotic, parasiticide.
- pharmaceutical item: 1 vial, bottle, tube, or container of any product.
- treatment: 1 entry on the treatment cards.
- valid veterinary-client-patient relationship: established when a veterinarian had examined and diagnosed the disease condition or had been involved with an operation to the extent that he/she was very aware of the conditions that existed on the farm and could diagnose "over the phone."

III. Analyses

All data were entered into Microsoft Excel[32] and all analyses (Tables 1-4) were performed using JMP statistical software[33]. When necessary, homogeneity of variances was tested using Levene's test.

A. Initial Mailing Results

Responses to the questionnaire sent with the introductory letter were analyzed for differences between producers interested in participating and those not interested in participating in the study. Comparisons of flock size, production type and lambing time were made to evaluate the potential for volunteer bias. Flock sizes were compared using the Wilcoxon Rank Sum test. Production types were categorized as purebred only, commercial only or both purebred and commercial. Production types were compared between participants and non-participants using Chi-square tests. Lambing season was categorized as fall only, winter only, spring only and multiple seasons and comparisons were made using Chi-square tests.

B. Study Completion

Results obtained from the interview were analyzed to determine differences between producers who completed the four-month recording period and those who did not. Length of time that producers had owned sheep was categorized into 10 years or less and 11 years or more. Breed and lambing season were categorized as above. Methods used to analyze the variables are listed in Table 1.

C. Description of Participants

Interview responses of participants who completed the four-month recording period were summarized using descriptive statistics. Results obtained from the pharmaceutical inventory were summarized by categorizing each product based on the active pharmaceutical agent in the product and how that agent was classified in the 4th edition of the Compendium of Veterinary Products[31]. Additionally, each product was categorized as either expired or not expired based on the product's expiration date. Descriptive statistics were used to summarize the results.

D. Recorded Treatments

Flock size was divided into the following categories: 1-49 (number of flocks, n=20), and 50 and greater (n=19). Products were categorized as above; categories included analgesic, antibiotic, antifungal, antihistamine, anti-inflammatory, dietary

supplement, disinfectant, electrolytes, hormone, insecticide, miscellaneous, parasiticide, vitamin/mineral supplement and vaccine. Miscellaneous products included any unknown products or ones that were not listed in the Compendium of Veterinary Products. Reasons for treatment were also categorized by type[29] and included dietary supplementation, gastrointestinal system, miscellaneous condition, miscellaneous infection, musculoskeletal system, parasite control, prevention, reproductive system, supplementation, vaccination. Descriptive statistics were used to summarize the recorded treatments.

The number of treatments per 100 sheep per month was determined for each participant. This was calculated by dividing the total number of treatment events on the farm by the number of sheep on the farm at the time of the interview, multiplying by 100 and dividing by 4. The effect that interview responses had on the number of treatments per 100 sheep per month was determined using tests listed in Table 2. Additionally, the number of non-vaccine treatments per 100 sheep per month was calculated for each participant as above, using only treatments made with non-vaccine product types. The effect that vaccination practices (as reported in the interview) had on this number was determined by using the Wilcoxon Rank Sum test, the t-test and Welsh ANOVA.

The number of product types used per 100 sheep per month for the four most frequent types of products administered was calculated for each producer by dividing the number of treatments using each product type by the number of sheep present on the farm at the time of the initial interview, multiplying by 100 and dividing by 4. The associations of that flock size, production type, valid veterinary-client-patient relationship, written records and extra-label drug usage and the number of product types used per 100 sheep per month were determined using the Kruskal-Wallis test, Wilcoxon Rank Sum test and t-test.

The number of condition types treated per 100 sheep per month was calculated for respiratory conditions, reproductive conditions, miscellaneous conditions and musculoskeletal conditions. This number was calculated for each producer by dividing the number of treatments attributed to each type of condition by the number of sheep present on the farm at the time of the initial interview, multiplying by 100 and dividing by 4. The associations of that flock size, production type, valid veterinary-client-patient

relationship, written records and extra-label drug usage and the number of condition types treated per 100 sheep per month were determined using the Kruskal-Wallis test and Wilcoxon Rank Sum test.

E. Price of Treatments

Information on product prices was obtained from prices listed in Jeffers catalog[34] and PBS Animal Health catalog[35], 2 livestock supply catalogs commonly used by sheep producers. Several producers recorded the amount of product given as a dosage, such as 1ml per 10 pounds. An average weight of 150 pounds per ewe and 75 pounds per lamb was used to calculate the actual amount of product administered for these treatments. Descriptive statistics were used to summarize the cost of animal treatment over the recording period.

Table 1. Statistical tests used to analyze differences between producers who did and did not complete the four-month recording period of the study.

Variable	Test
Interview method	Fisher's Exact
Flock size	Wilcoxon Rank Sum
Length of time in sheep industry	Fisher's Exact
Animal identification	Fisher's Exact
Written records kept on animal treatments	Fisher's Exact
Extra-label drug use	Fisher's Exact
Valid veterinary-client-patient relationship	Fisher's Exact
Lambing season	Fisher's Exact
Breed	Chi-square

Table 2. Statistical tests used to analyze the effect of interview responses on the number of treatments per 100 sheep per month.[1]

Variable	Test
Month of enrollment	ANOVA
Flock size	t-test
Breed	ANOVA
Written records kept on individual animal treatments	t-test
Valid veterinary-client-patient relationship	t-test
Drugs used in an extra-label manner	t-test
Utilization of a deworming protocol	Wilcoxon Rank Sum
Feed additives used	t-test
Routinely vaccinated against reproductive diseases	t-test
Routinely vaccinated against clostridial diseases	t-test
Routinely vaccinated against respiratory diseases	t-test

[1] The number of treatments per 100 sheep per month was calculated for each producer by dividing the total number of treatments given by that producer during the four-month recording period by the number of sheep present at the time of the interview, multiplying by 100 and dividing by 4.

Selection of Participants

I. Results

Initial Mailing

Of the 274 introductory letters sent in the initial mailing, 120 (43.8%) were returned. Sixty-four of the 120 producers who responded (53.3%) were interested in participating in the study. Twenty-three of the 120 respondents (19.2%) no longer owned sheep so were not included in further analyses.

There were no differences in mean flock size (Table 3), production type or lambing season (Table 4) for those who were interested and those who were not interested in participating in the study.

Study Completion

Of the 64 producers who were interested in participating in the study, 6 could not be contacted to interview, so a total of 58 producers began the study. Of these, 39 completed the four-month recording period. The following variables were similar ($p>0.10$) for producers who did and did not complete the recording period (Tables 5 and 6): interview method, length of time in the sheep industry, identification of all sheep, maintenance of written records of individual animal treatments, usage of drugs in an extra-label fashion, involvement in a valid veterinary-client-patient relationship and lambing season. Producers who completed the study had a smaller average flock size than those who didn't complete the study ($p=0.06$, Table 5). Production type was different for the two groups ($p=0.02$), with producers who completed the study being more likely to own commercial crossbreeds only, while those who did not complete the study were more likely to produce both pure and crossbred sheep (Table 6).

II. Discussion

The 1997 Agriculture Census of Virginia reported that there were 1456 sheep farms with a total of 73,932 sheep in the Commonwealth of Virginia[36]. Using 1997 information, producers in this study would represent 2.7% of the sheep farms and 4.0% of the sheep in Virginia. However, because both the number of sheep and the number of

farms that produce sheep have been steadily decreasing in recent years, it is likely that participants in this study represent a larger proportion of Virginia sheep producers than estimated. Producers contacted for participation included shepherds who attended sheep conferences, were members of the Virginia Sheep Producers Association or were involved in the wool pool. These producers may be considered more active in the sheep industry than producers who were not contacted for participation. Because of this, participants may have been more knowledgeable of the issues surrounding drug use in food animals or may have used pharmaceuticals within their sheep flocks in a way that is different from producers who have less involvement in the sheep industry. Results obtained in this study may have been affected by these differences.

All producers who were contacted had a choice of whether or not to participate in the study. Although responses to the initial mailing showed no differences in flock size, production type or lambing season, factors not considered in this study may have influenced a producer's choice to participate.

Producers who completed the study had a smaller average flock size than producers who did not complete the study. Producers with larger flocks may have had other farm enterprises and felt that the time commitment required for the study was too great for completion of the study. Using data from the 1997 Agriculture Census of Virginia, the average flock size in Virginia is approximately 50 sheep[36]. Participants in this study had a larger average flock size (76 head) than the Virginia average. However, because flock size was not found to affect the number or types of treatments per sheep for producers who completed the study, it is unlikely that the collection of data from producers with larger or smaller sized flocks would have had a major impact on the results of the study.

Table 3. Comparison of flock size for producers who responded to the initial mailing, which included a description of the study, a request to participate in the study and a brief questionnaire to return regardless of interest in the study.

Interested in participating in the study	Number	Median flock size (range)	Mean flock size	Range	p-value[1]
Yes	64 (53.3%)	53	84.0	10-500	0.11
No	33 (27.5%)	32	69.2	6-500	
No longer own sheep	23 (19.2%)	----------	----------	----------	

[1] Wilcoxon Rank Sum test

Table 4. Comparison of producers who responded to the initial mailing, which included a description of the study, a request to participate in the study and a brief questionnaire to return regardless of interest in the study.

	Interested in participating		Not interested in participating		
Characteristic	**n**	**%**	**n**	**%**	**p-value[1]**
Production type[2]					0.29
Purebred only	39	61.9	25	75.8	
Commercial only	21	33.3	6	18.2	
Both	3	4.8	2	6.0	
Lambing Season					0.12
Winter only	18	28.1	14	42.4	
Spring only	27	42.2	15	45.5	
Multiple	19	29.7	4	12.1	

[1] Chi-square test
[2] One producer who was interested in participating in the study did not indicate the production type used within the flock. Therefore, the total number of responses to that question for interested producers is 63.

Table 5. Comparison of flock size of producers who did and did not complete the four-month recording period of the study.

		Number of sheep			
	Number of producers	**Mean**	**Median**	**Range**	**p-value[1]**
Completed study					0.06
Yes	39	76.6	47	10-550	
No	19	113.6	80	12-350	

[1] Wilcoxon Rank Sum

Table 6. Comparison of 39 producers who completed the four month recording period and 19 producers who did not complete the recording period of the study.

Variable	Completed		Did not complete		p-value
	n	%	n	%	
Interview Method					0.10[1]
Phone	17	43.6	13	68.4	
In person	22	56.4	6	31.6	
Length of time in the sheep industry					1.00[1]
10 years or less	16	41.0	7	36.8	
11 years or more	23	59.0	12	63.2	
Are all sheep identified					0.54[1]
Yes	36	92.3	19	100.0	
No	3	7.7	0	0.0	
Are written records kept on all animal treatments					0.14[1]
Yes	14	35.9	3	15.8	
No	25	64.1	16	84.2	
Are drugs used in an extra-label fashion					0.65[1]
Yes	34	87.2	18	94.7	
No	5	12.8	1	5.3	
Do you have a valid veterinary-client-patient relationship					1.00[1]
Yes	33	84.6	16	88.9	
No	6	15.4	2[2]	11.1	
Lambing season					0.58[1]
One season	20	51.3	8	42.1	
Multiple seasons	19	48.7	11	57.9	
Production type					0.02[3]
Commercial only	16	41.0	2	10.5	
Purebred only	9	23.1	3	15.8	
Both commercial and purebred	14	35.9	14	73.7	

[1] Fisher's Exact test
[2] One producer who did not complete the study was unable to answer the question regarding a valid veterinary-client-patient relationship. Therefore, the total number of responses for producers who did not complete the study for this question was 18.
[3] Chi-square test

Interview Responses

I. Results

General Characteristics

Producers who completed the four-month recording period had a median flock size of 47 ewes (range 10 to 550). Over half of the producers (n=23) had been involved in the sheep industry for eleven or more years (Table 7). Thirty participants (76.9%) produced commercial crossbred sheep (Table 6). The most commonly produced purebred sheep were Dorsets (number of producers, n=11) and Suffolks (n=9). Thirty-three (84.6%) of the sheep flocks had a spring lambing season (Table 7). Lambs were produced for a variety of purposes, including meat (n=39), club lambs (n=18), breeding stock (n=17) and wool (n=12).

All animals were identified on 36 farms, but only 14 participants kept written records on all animal treatments (Table 6). The most common information recorded by those who kept written records included animal identification (n=14) and product administered (n=14). One participant recorded the date animals could be shipped after treatment, but none indicated the withdrawal time of the product used (Table 7).

Medications and Animal Treatment

Medications used by participants in the study were purchased from a combination of sources, including feed stores (n=34), veterinarians (n=32) and catalogs (n=25) (Table 8). Participants in the survey indicated that less than one curative treatment was given to the flock per month (median 0, range 0 to 10). Intra-muscular (IM) injections were given primarily in the top of the hip (n=18) and the neck (n=18). Five participants gave no IM injections to their sheep flock. Subcutaneous (SQ) injections were administered primarily in the neck (n=29) and under the elbow (n=22). One producer gave no SQ injections to their sheep flock.

Thirty-three producers reported that they had established a valid veterinary-client-patient relationship for the veterinary care of their flocks (Table 7). Thirty-four participants used drugs in an extra-label fashion, and 23 of those indicated that extra-label drug use occurred only under the direction of a veterinarian (Table 8). The veterinarian was the most commonly utilized source of information regarding drug usage and

treatment decisions for the flock (n=37), followed by extension agents or other extension services (n=30) and other producers (n=23).

Conditions Observed

Producers were surveyed to determine the occurrence of 14 conditions within their sheep flocks (Tables 9 and 10, Figure 1). Two participants reported seeing no problematic conditions in their sheep within the past two years. Internal parasites was the most frequent condition observed (n=26), followed by difficult lambing (n=25), mastitis (n=21) and lameness (n=19). More than half of the producers who had problems associated with difficult lambing, ketosis, animals going off-feed and "other" conditions called a veterinarian for assistance with the treatment of those conditions. For all conditions listed, more than half of producers who had observed the condition within their sheep flock had developed a standard treatment protocol for that condition. The veterinarian and the owner played the largest roles in development of the treatments for the conditions, with extension services playing a smaller role in treatment development (Table 11).

Vaccination, Supplementation and Deworming

Thirty-seven participants vaccinate for *Clostridium perfringens* C and D and 34 vaccinate for tetanus (Table 12). The next most frequent conditions vaccinated for included respiratory diseases (n=6), chlamydia (n=6), and campylobacter (n=5). Two participants administered no vaccines in their sheep flock. Eighteen of 39 producers relied on previous experience when planning their vaccination protocol. Additional sources of information included veterinarians (n=16), extension services (n=14), other producers (n=2) and textbooks (n=2).

Nineteen participants administer injectable vitamin E and Selenium to their sheep. Vitamin E and Selenium injections were given to lambs within one month of birth (n=17) and to ewes prior to lambing (n=8), prior to breeding (n=2) and after lambing (n=1). Nine participants administered the supplement to their sheep at more than one time.

Thirty-seven out of 39 participants reported utilizing a standard deworming protocol (Table 13). Eighteen out of 39 producers relied on previous experience when

determining their deworming protocol. Veterinarians (n=16), extension agents/services (n=13), other producers (n=2) and textbooks (n=2) also played a role in protocol development. Twenty producers used ivermectin drench and 16 producers used ivermectin injection. Other commonly used products included albendazole (n=13), levamisole hydrochloride (n=11) and fenbendazole (n=8). Twenty-two participants dewormed their ewes at lambing. Sixteen participants reported deworming their ewes every 4 weeks during the grazing season. Nineteen participants deworm lambs every 4 weeks during the grazing season (Table 13).

The most frequent treatment administered to lambs after birth is dipping the navel in iodine (n=35), followed by vitamin E/selenium injection (n=16), nutritional supplementation (n=12) and clostridial vaccination (n=7). Three participants reported giving no treatments to lambs after birth and one participant routinely administered spectinomycin to lambs after birth.

Nineteen participants did not use feed additives to treat their flocks. The most frequently used feed additives were lasalocid (n=16), aureomycin (n=10) and amprolium (n=3).

II. Discussion

Results from this study allow the summary of the general characteristics of a subset of Virginia sheep producers. Participants had a wide range of experience with sheep and produced both pure and cross-bred sheep for a variety of purposes. One area of concern is that only 14 producers reported maintaining written records on individual animals treated with drugs. Of those producers that did keep records, none recorded the withdrawal time of the drug that was administered. This is of additional concern because all producers reported producing lambs for meat. Additionally, although 33 participants reported having established a valid veterinary-client-patient relationship, only 23 participants who administered drugs in an extra-label fashion reported that it was done so under the direction of their veterinarian only. The maintenance of written records and establishment of a valid veterinary-client-patient relationship are two areas that have been identified in quality assurance programs to help reduce the occurrence of violative residues in animal products[1,2,8].

Five producers reported administering no intra-muscular injections to their sheep and one producer reported administering no subcutaneous injections to their sheep. Many pharmaceuticals and biologics are labeled for one type of injection route, so any other route of administration would be considered extra-label. For example, all clostridial vaccines are labeled for subcutaneous injection only. However, the producer who reported giving no subcutaneous injections also reported that no vaccines were routinely administered to their sheep flock.

The most common conditions observed by study participants over the past two years included internal parasites, dystocia, mastitis and lameness. These conditions are similar to the conditions most frequently reported in the 1996 NAHMS Sheep Survey: internal parasites, mastitis and footrot. Fewer study participants (23.1%) reported observing foot rot in their sheep flock when compared to participants in the NAHMS study (40.5%). Additionally, two participants reported observing no problematic conditions within their flocks in the previous two years. Both of these participants had small flocks (less than 15 sheep) and had been producing sheep for less than 5 years, so they may not have produced sheep long enough for many problems to arise. Only 26 participants reported observing internal parasites within their flocks in the previous two years, which seems low when 37 participants reported utilizing a standard deworming protocol. Many producers may have considered parasites a routine part of sheep production and not reported problems associated with parasites during the interview. Additionally, producers may have had a difficult time recalling conditions observed over the large time span of two years. Conditions may have been underreported as a result.

Many producers reported that veterinary assistance was not obtained in the treatment of the conditions asked about in the survey. This suggests that veterinarians are either not available to treat sheep or that hiring of veterinarians is not an economically feasible option.

Many participants reported administering preventive treatments to lambs after birth, including dipping the navel, and nutritional supplementation, suggesting that participants in this study are concerned about disease prevention. Seven participants reported administering clostridial vaccines to newborn lambs. Because of the presence of a vaccinated mother's antibodies, vaccination of lambs at birth may not provide

additional disease protection. One participant reported routinely giving spectinomycin injections to lambs after birth. This is of concern because the over-use of antibiotics may contribute to the development of resistant strains of bacteria[22].

Virginia Cooperative Extension recommends vaccinating ewes for *Clostridium perfringens* type C and D and *Clostridium tetani* 4 weeks prior to lambing, and vaccinating ewes for chlamydia and campylobacter prior to breeding[37]. All producers who vaccinated for *Clostridium perfringens C* and *D* and campylobacter and chlamydia administered the vaccines at the recommended times. Over 75% of producers who vaccinated for tetanus vaccinated at the recommended time. Other times that tetanus vaccines were administered included at birth and at tail docking or castration. Vaccines administered at times other than those recommended may provide no increased protection against disease and may increase the costs associated with treatment without providing additional benefit.

Many producers (15.4%) reported vaccinating their sheep against respiratory vaccines, even though the vaccines used were not approved for use in sheep and respiratory vaccines are not part of the extension services vaccination protocol[37]. The reason for this may be that 15 of the 39 participants reported observing respiratory conditions within their flock in the previous two years.

The 1996 NAHMS sheep health report found that approximately 18% of sheep producers expressed high or moderate concern for disease-related abortions in their ewes[27]. Additionally, many producers in this study had observed some type of reproductive problems within their flock in the previous two years, so they might be expected to be very aware of the reproductive health of their flock. However, in the survey, only 15.4% of participants reported vaccinating against chlamydia and 12.8% of producers reported vaccinating against campylobacter. This is comparable to the number of producers (15.4%) who vaccinated against reproductive diseases during the course of the study. Producers may have viewed reproductive vaccines as being too expensive for routine use until specific diseases had been observed on their farms.

Virginia Cooperative Extension recommends deworming ewes prior to lambing and every 8 weeks during the grazing season and deworming lambs every 3 to 4 weeks during the grazing season[37]. Twenty-six producers dewormed their ewes prior to or just

after lambing. Twenty-eight producers were following the recommended time intervals for deworming ewes during grazing season and 23 producers were deworming lambs at the recommended time intervals. Thirty-three producers reported regularly using parasiticides that are not approved for use in sheep. This may indicate that effective, approved parasiticides are needed for the sheep industry. All producers in this study recorded treatments made with parasiticides, but only 26 producers (66.7%) reported problems associated with internal parasites in their flock during the previous two years. This discrepancy could partially be explained by the fact that 37 producers had a standard deworming protocol so may have observed symptoms of intestinal parasites less frequently. Five producers recorded the administration of parasiticides less frequently than expected, based on the deworming protocol they reported during the interview; all of these producers dewormed their ewes and lambs every 8 weeks when they reported deworming every 4 weeks. This could be due either to errors in the data collection method (treatments weren't recorded on the treatment card) or problems recollecting the information during the interview (producers don't deworm as often as they think they do). Increased record keeping could help producers more accurately maintain their scheduled deworming protocol.

Timely administration of vaccines and parasiticides may be an indication that producers are aware of recommended practices and are dedicated to preventing disease within their flocks. Interest in disease prevention may exist not only for these specific diseases, but also extend to all health issues. Additionally, the routine administration of vaccines and dewormers may cause fewer medical problems to occur within flocks, resulting in the low number of treatments per sheep observed during the study.

Table 7. Characteristics of 39 participants who completed the four-month recording period of the study.

Characteristic		n	%
Length of time in sheep industry			
	0-5 years	8	20.5
	6-10 years	8	20.5
	11-20 years	10	25.7
	More than 20 years	13	33.3
Lambing season[1]			
	Spring (March-May)	33	84.6
	Winter (December-February)	13	33.3
	Fall (September-November)	9	23.1
	Non-seasonal	1	2.6
Lambs produced for[1] . . .			
	Meat	39	100.0
	Wool	12	30.8
	Club lambs	18	46.2
	Breeding stock	17	43.6
	Multiple markets	29	74.4
Type of identification used[1,2]			
	Eartag	34	94.4
	Ear notches	4	11.1
	Tattoo	3	8.3
	Other means of identification	3	8.3
	Only one form of identification used	2	74.3
Of those that keep written records on animal treatments, the number that recorded[1,1] . . .			
	Animal identification	14	100.0
	Drug administered	14	100.0
	Amount of drug administered	9	64.3
	Route of administration	3	21.4
	Date animal can be shipped	1	7.1
	Withdrawal time	0	0.0

[1] Producers may have selected more than one category.
[2] Out of 36 producers who identify all animals (see Table 6).

Table 8. Characteristics of medication usage and animal treatment of the 39 producers who completed the four-month recording period.

Characteristic	n	%
Source of medication[2]		
Feed store	34	87.2
Veterinarian	32	82.1
Catalog	25	64.1
Borrow from other producers	1	2.6
More than one source	35	89.7
Needles used[1]		
Disposable, multiple use	27	69.2
Disposable, single use	17	43.4
Re-usable, multiple use	4	10.3
More than one type used	8	20.5
Sites used for IM injections[1]		
Top of hip	18	46.2
Neck	18	46.2
Hind leg	11	28.2
Shoulder	6	15.4
No IM injections given	5	12.8
Sites used for SQ injections[1]		
Neck	29	74.4
Under the elbow	22	56.4
Behind the shoulder	10	25.6
Inside hind leg	7	17.9
Over the ribs	3	7.7
Thigh	1	2.6
Wherever is convenient	1	2.6
No SQ injections given	1	2.6
Extra-label drug use		
Drugs are used in an extra-label fashion	34	87.2
Drugs used extra-label are given under the direction of a veterinarian	23	67.6[3]
What sources are used for information about drug use and treatment decisions[1]		
Veterinarian	37	94.9
Extension agents/services	30	76.9
Other producers	23	59.0
Magazine/trade journal	22	56.4
Textbooks	18	46.2
Sheep industry handbook	16	41.0
Internet	8	20.5
Feed salesman	5	12.8
Merck manual	1	2.6

[1] Out of 14 producers who keep written records of individual animal treatments (see Table 6).
[2] Producers may have selected more than one category.
[3] Out of 34 producers who use drugs in an extra-label fashion.

Table 9. Conditions observed in 39 Virginia sheep flocks during the previous 2 years (1999-2001).

Condition	Number of flocks in which condition was observed		Number of producers who call a veterinarian for assistance with the condition[1]		Number of producers who have developed a standard treatment for the condition[1]	
	n	%	n	%	n	%
Internal parasites	26	66.7	6	23.1	26	100.0
Difficult lambing	25	64.1	13	52.0	20	80.0
Mastitis	21	53.8	4	19.0	18	85.7
Lameness	19	48.7	4	21.1	18	94.7
Pneumonia	15	38.5	7	46.7	14	93.3
Other	15	38.5	10	66.7	11	73.3
Diarrhea/scours	12	30.8	2	16.7	12	100.0
Off feed	10	25.6	5	50.0	7	70.0
Ketosis	9	23.1	5	55.5	9	100.0
Foot rot	9	23.1	2	22.2	8	88.9
External parasites	8	20.5	3	37.5	5	62.5
Retained placenta	5	12.8	2	40.0	5	100.0
Pink eye	3	1.7	1	33.3	3	100.0
No conditions seen	2	5.1	----------	----------	----------	----------
Polio	1	2.6	0	0.0	1	100.0

[1] Question asked only of producers who had observed the condition within their flock in the previous 2 years.

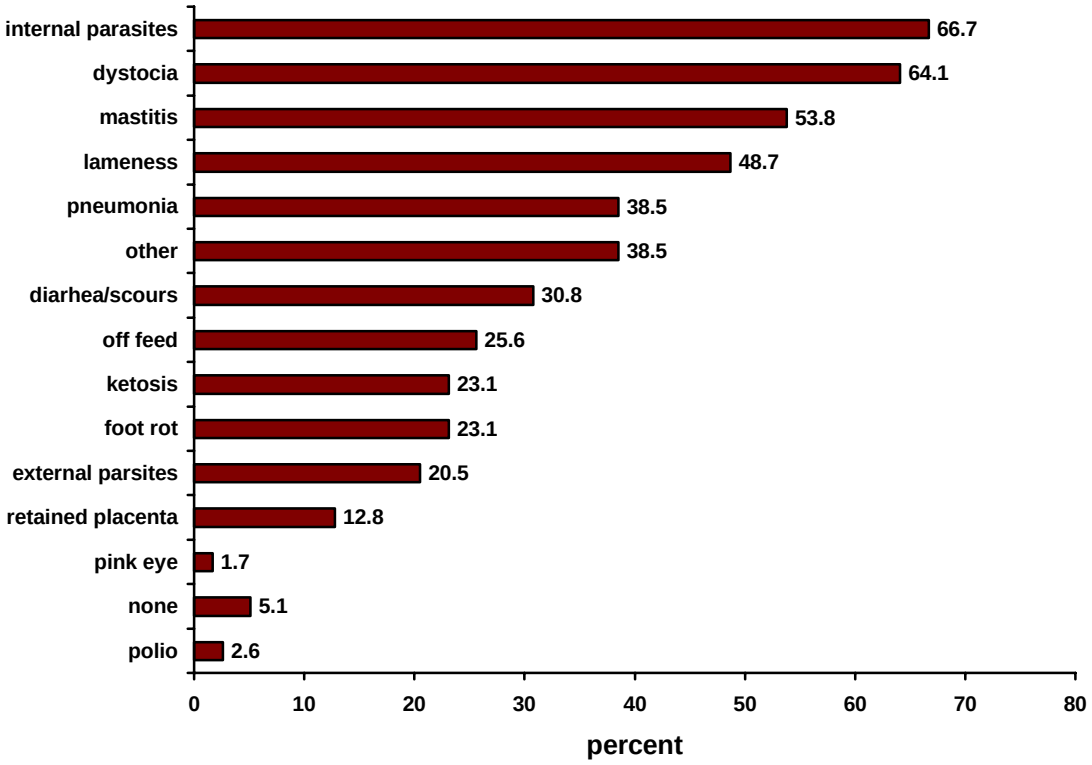

Figure 1. Conditions observed within 39 Virginia sheep flocks during the previous 2 years (1999-2001).

Table 10. "Other" condition types observed in 39 Virginia sheep flocks during the previous 2 years (1999-2001).

	producers observing condition	
Condition	**n**	**%**
Entropion	3	7.7
Soremouth	2	5.1
Vitamin/mineral deficiency	2	5.1
Anemia	1	2.6
Boils	1	2.6
Chlamydia	1	2.6
Clostridia	1	2.6
Deerworm	1	2.6
Flystrike	1	2.6
Lysteria	1	2.6
Klebsiella	1	2.6

Table 11. Development of standard treatment plans for 14 conditions observed by 39 participants in the previous 2 years (1999-2001).

Condition	Number of producers with a standard treatment for the condition[1]	Individual who influenced the development of the standard treatment plan[2]					
		Veterinarian		Owner/manager (previous experience)		Extension agent/services	
		n	%	n	%	n	%
Internal parasites	26	11	42.3	18	69.2	6	23.1
Dystocia	20	14	70.0	14	70.0	4	20.0
Mastitis	18	12	66.7	12	66.7	1	5.6
Lameness	18	6	33.3	12	66.7	1	5.6
Pneumonia	14	11	78.6	7	50.0	2	14.3
Diarrhea/scours	12	9	75.0	7	58.3	1	8.3
Other	11	8	72.7	3	27.3	0	0.0
Ketosis	9	6	66.7	2	22.2	2	22.2
Foot rot	8	3	37.5	5	62.5	3	37.5
Off feed	7	4	57.7	4	57.1	0	0.0
External parasites	5	3	60.0	2	40.0	1	20.0
Retained placenta	5	3	60.0	2	40.0	0	0.0
Pink eye	3	3	100.0	1	33.3	1	33.3
Polio	1	0	0.0	1	100.0	1	100.0

[1] Only producers who had observed the condition within their flock in the previous 2 years were asked questions regarding the development of standard treatment.
[2] Producers may have selected more than one response.

Table 12. Vaccination practices of 39 participants who completed the four-month recording period.

	Clostridium		Tetanus		Respiratory		Chlamydia		Campylobacter		None	
	n	%	n	%	n	%	n	%	n	%	n	%
Number of producers who administer vaccine	37	94.9	34	87.2	6	15.4	6	15.4	5	12.8	2	5.1
Dosage administered												
Labeled dose	33	89.2	30	88.2	3	50.0	5	83.3	4	80.0	--	------
Other than labeled dose	1	2.7	1	2.9	3[1]	50.0	0	0.0	0	0.0	--	------
Unable to answer	3	8.1	3	8.8	0	0.0	1	16.7	1	20.0	--	------
Time of administration[2]												
Pre-breeding	0	0.0	1	2.9	0	0.0	6	100.0	5	100.0	--	------
Pre-lambing	37	100.0	26	76.5	4	66.7	0	0.0	0	0.0	--	------
Weaning	6	16.2	6	17.6	0	0.0	0	0.0	0	0.0	--	------
Other	31	83.8	26	76.5	5	83.3	0	0.0	0	0.0	--	------

[1] The vaccine used by these 3 producers is approved for use in cattle, but not sheep. Producers who reported using the labeled dose were administering the dosage approved for cattle.

[2] Producers may have selected more than one response for time of administration. Percentages for time of administration are the number who vaccinate at a particular time divided by the number of producers who administer vaccines for the particular conditions.

Table 13. Deworming practices of 37 participants who indicated use of a deworming protocol.

	n	(%)
Sources of information when planning the deworming protocol[1]		
Flock owner or manager	18	48.6
Veterinarian	16	43.2
Extension agent/services	13	35.1
Textbooks	2	5.4
Other producers	2	5.4
Which dewormers are used[2]		
Ivermectin drench	20	54.1
Ivermectin injection	16	20.1
Albendazole	13	16.9
Levamisole hydrochloride	11	14.3
Fenbendazole	8	10.4
Doramectrin	6	7.8
Moxidectin	1	*2.7*
Oxfendazole	1	2.7
Seaweed	1	2.7
Frequency of deworming[1]		
Ewes		
At lambing	22	59.5
Every 4 weeks while grazing	16	43.2
Every 8 weeks while grazing	9	24.3
At breeding	4	10.8
Lambs		
Every 4 weeks while grazing	19	21.4
Every 8 weeks while grazing	9	24.3
Other		
As needed	7	18.9
Two times a year	3	8.1
Every 4-10 weeks during cold months	3	8.1
Four times a year	2	5.4
After the first frost	1	2.7

[1] Producers may have selected more than one response.
[2] Producers may have listed more than one dewormer as being used.

Pharmaceutical Inventory

I. Results

A total of 324 pharmaceutical items were inventoried during site visits at 26 farms (Table 14). Zero to 32 pharmaceutical items were found on each farm (median 9.5). Two producers kept no pharmaceuticals on hand. Twenty-four producers had antibiotics and vaccines on their farms. The least frequent product type inventoried were antifungals, which were kept in stock by 1 participant. A total of 80 products had expired. The majority of these were antibiotics (n=31), vitamin/mineral supplements (n=14) and miscellaneous products (n=10). Nineteen products were labeled with veterinary information. All of the labels included the veterinarian's name and address as well as instructions concerning the use of the product. Antibiotics were the most frequent product containing a veterinarian label (n=8).

FDA labeling information was available for 299 of the pharmaceutical items inventoried. One hundred sixty seven of the pharmaceutical items inventoried (55.9%) were labeled by the FDA for use in sheep. The percentage of unapproved pharmaceutical items was highest for anti-inflammatories, antifungals and disinfectants (100% unapproved each) as well as for miscellaneous products (63.6%), parasiticides (70.0%) and antibiotics (57.3%).

II. Discussion

Results of the pharmaceutical inventory revealed that most sheep producers keep antibiotics, parasiticides, vaccines and vitamin/mineral supplements on hand. Many producers reported having standard deworming and vaccination protocols, so these product types were expected to be the most frequently stocked. Slightly more than 25% of the pharmaceutical items kept in stock were expired. Twelve percent of parasiticides and vaccines were expired. Parasiticides and vaccines are used more frequently so would be more likely to be used before the expiration date, resulting in fewer expired parasiticide and vaccines being kept on hand. A large number of antibiotics were expired (34.8%). Antibiotics are purchased by most producers but are used less

frequently so would be more likely to expire. Expired products may be less effective in disease prevention or treatment, and could increase the chance of development of resistant organisms[38]. Less effective products could also necessitate more frequent product administration, leading to an increased chance of violative residue occurrence.

Only 55.6% of the pharmaceutical items kept in stock by producers were labeled for use in sheep. Antibiotics and parasiticides that were commonly stocked by producers were often not approved for use in sheep, suggesting that approved, effective antibiotics and parasiticides are needed within sheep production. Although 82.1% of participants reported buying pharmaceuticals from veterinarians, only 5.9% of the pharmaceuticals inventoried had been labeled with a veterinarian's name, address or directions for product usage. This could indicate that veterinarians are not labeling pharmaceuticals upon sale or that producers don't purchase many pharmaceuticals from veterinarians. This could also be influenced by whether the pharmaceutical is available over-the-counter or is available by prescription only. With the number of products that are used in an extra-label manner, the lack of a veterinarian's instructions on products could mean that producers have little veterinary input in decisions regarding usage and withdrawal times of extra-label products. This could increase the likelihood that products are being misused and increase the chance of violative residue occurrence in food products derived from sheep.

Table 14. Product types inventoried during 26 site visits.

Product type	Number of products	% of total	Number of products expired	Number of products with no expiration date[1]	Number of products labeled with veterinary information[2]	Number of farms on which the product type was found	Number of products for which FDA labeling information existed	
							n	%
Antibiotic	89	27.5	31	7	8	24	89	100.0
Parasiticide	50	15.4	6	5	2	21	50	100.0
Vaccine	47	14.5	6	1	0	24	47	100.0
Vitamin/mineral supplement	46	14.2	14	3	1	20	46	100.0
Miscellaneous	33	10.2	10	4	2	15	22	66.7
Disinfectant	18	5.6	4	0	0	9	6	33.3
Hormone	13	4.0	4	0	3	10	13	100.0
Nutritional supplement	12	3.7	1	1	0	9	11	91.7
Anti-inflammatory	8	2.5	3	1	3	6	8	100.0
Insecticide	7	2.1	1	1	0	4	6	85.7
Antifungal	1	0.3	0	0	0	1	1	100.0
Total	324	100	80	23	19	-----	299	92.3

[1] Includes products that did not have an expiration date as well as products with illegible expiration dates.
[2] Veterinarian information included name, address and instructions for product use.
[3] Percentage out of the number of products for which labeling information was available.

Recorded Treatments

I. Results

A total of 14,310 treatments were recorded by 39 producers in four-month periods, from March 3, 2001 through September 18, 2001. FDA labeling information existed for 14,165 (99.0%) of the treatments administered during the course of the study. The majority of treatments (98.2%) were administered by the participant.

Reasons for Treatment

The most common reason given for treatment was parasite control, which accounted for 9272 of all treatments administered (Table 15, Figure 2). This was followed by vaccination (n=2170), vitamin/mineral supplementation (n=1202) and treatment of reproductive conditions (n=457). All participants administered treatments for parasite control. Twenty-six participants vaccinated their sheep and 19 participants treated reproductive conditions and miscellaneous conditions. All of the treatments made for dietary supplementation were administered using products that had not been labeled by the FDA for use in sheep. The majority of treatments made for respiratory conditions (78.2%), gastrointestinal conditions (64.1%) and parasite control (58.4%) were made with products that were not labeled for use in sheep.

Products Administered

The products most frequently administered over the course of the study were ivermectin (n=3645), albendazole (n=2474), clostridial vaccines (n=1935), levamisole (n=1708) and vitamin E/selenium (n=1072). All participants reported using parasiticides to treat their sheep (Table 16). Twenty-nine participants used antibiotics, 26 used vaccinations and 20 used vitamin/mineral supplements. Approximately half (n=7771, 45.1%) of the treatments administered were with products labeled for use in sheep.

The most common type of product administered were parasiticides, which accounted for 9284 (64.9%) of the recorded treatment events (Table 16, Figure 3). Ivermectin products accounted for 3645 (39.3%)of treatments with parasiticides. Albendazole (n=2474) and levamisol (n=1708) were the next most frequent dewormers

used. Over half (n=5455, 58.8%) of the parasiticide treatments administered were not labeled for use in sheep.

The second most common product type administered was vaccines, which accounted for 2182 (15.2%) of all treatments administered (Table 16, Figure 3). One thousand nine hundred thirty five (88.6%) of the vaccinations administered were clostridial vaccines. The next most frequent vaccine administered was pasteurella bacterin (n=80). Few (n=46, 2.1%) of the vaccination treatments administered were made using products that were not labeled for use in sheep.

Vitamin/mineral supplements were the third most frequently administered product type, accounting for 1254 (8.8%) of the total number of treatments administered (Table 16, Figure 3). Vitamin E and Selenium combinations accounted for 1072 (85.5%) of the supplements administered. The next most frequent type of vitamin/mineral supplement was vitamin B (n=172), followed by vitamins A and D (n=8). Three hundred twenty three (25.8%) of the treatments made using supplements were with products labeled for use in sheep.

Antibiotics were the fourth most frequently administered type of product, accounting for 976 (6.6%) of all products administered (Table 16, Figure 3). The most commonly used antibiotics were aureomycin (n=300) and penicillin (n=267). Three hundred thirty five (34.3%) of the antibiotic treatments used were made using products labeled for use in sheep.

II. Discussion

The most common reasons for treatment during the course of the study included parasite control, vaccination and vitamin/mineral supplementation, revealing that treatment of sheep flocks is primarily of a preventive nature. Curative treatments occurred for reproductive, musculoskeletal, miscellaneous and respiratory conditions, suggesting that approved, effective products are needed to treat these conditions.

During the interview, most producers estimated the pharmaceutical usage within their flocks to be very small. When asked to estimate the average number of treatments (not including routine deworming and vaccination) administered to their flock each month, the median response was zero. However, only 8 participants administered

only parasiticides and vaccinations during the course of the study. Participants may have underestimated the number of pharmaceuticals given to their sheep flocks because few keep written records of animal treatments.

Only 54.9% of all treatments administered over the course of the study were made using products labeled for use in sheep. Slightly less than half (46.9%) of the treatments made using parasiticides, vitamin/mineral supplements and antibiotics consisted of products approved by the FDA for use in sheep. Because treatment with these products accounted for a large portion of the total treatments administered, sheep in the study may have been given some products for which little research concerning withdrawal time and residue occurrence in sheep had been conducted. This is of concern since all of the producers who took part in this study marketed their sheep for meat. Only 26 participants administered vaccines to their sheep during the course of the study, while 37 participants reported the routine administration of vaccinations during the interview. The number of producers who recorded vaccine administration may have been affected by the time period during which the study took place. Most of the study participants utilized a spring lambing season, so any vaccinations given prior to breeding would not have been recorded on the treatment cards. The number of parasiticides and vitamin/mineral supplements may also have been affected by the time span of the study. Most of the ewes in the study were lambing while treatments were being recorded. Participants often deworm ewes prior to or after lambing and many newborn lambs are given vitamin E/selenium injections. Parasite control is also more frequent during the warmer months when sheep are grazing. This study took place between March and September, potentially capturing the peak times of pharmaceutical and biologic administration. The number of treatments with parasiticides, vaccines and vitamin/mineral supplements, as well as the total number of treatments administered would likely be lower during other times of the year.

Table 15. Reasons for treatments administered by 39 Virginia sheep producers who recorded animal treatments for 4 months.

Reason for treatment administration	Number of treatments administered[1]		Farms reporting treatment of condition[2]		Number of treatments for which FDA labeling information existed	Treatments made using products not labeled for use in sheep	
	n	%	n	%		n	%[3]
Parasite control	9272	64.8	39	100.0	9272	5411	58.4
Vaccination	2170	15.2	26	67.7	2170	36	1.7
Vitamin/mineral supplementation	1202	8.4	15	38.5	1202	324	27.0
Reproductive system	457	3.2	19	48.7	446	52	11.7
Musculoskeletal system	251	1.8	15	38.5	219	43	19.6
Miscellaneous condition	237	1.7	19	48.7	187	61	32.6
Respiratory system	207	1.4	12	30.8	206	161	78.2
Dietary supplementation	160	1.1	2	5.1	160	160	100.0
Gastrointestinal system	149	1.0	12	30.8	145	93	64.1
Prevention	144	1.0	7	17.9	111	42	37.8
Miscellaneous infection	61	0.4	12	30.8	47	11	23.4
Total	14310	-----	-----	-----	14165	6394	45.1

[1] A total of 14310 treatments were recorded.
[2] A total of 39 farms recorded information on treatments over a four-month period.
[3] Percentage of the number of treatments for which labeling information was available.

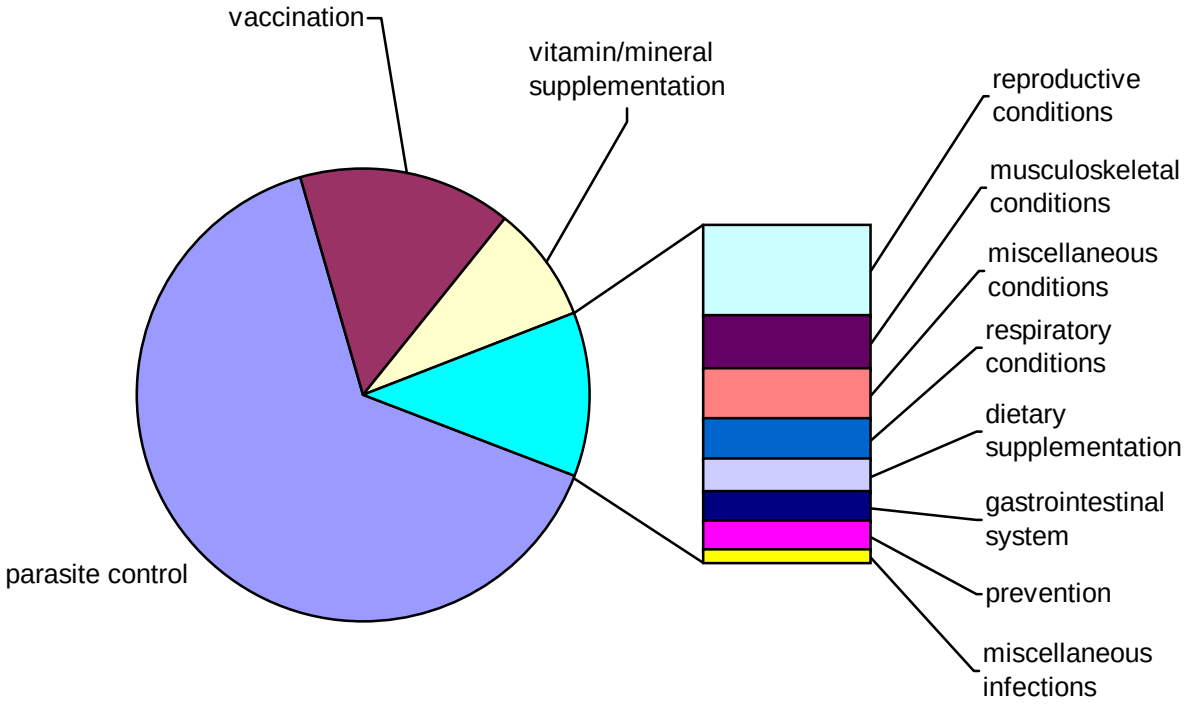

Figure 2. Reasons for treatments administered by 39 Virginia sheep producers who recorded animal treatments for 4 months.

Table 16. Types of products administered by 39 Virginia sheep producers who recorded animal treatments for 4 months.

Type of product administered	Number of administrations[1]		Number of farms reporting use of product[2]		Number of administrations for which FDA labeling information existed	Administrations made using products not labeled for use in sheep	
	n	%	n	%		n	%
Parasiticide	9284	64.9	39	100.0	9284	5455	58.8
Vaccine	2182	15.2	26	66.7	2182	46	2.1
Vitamin/mineral supplement	1254	8.8	20	51.3	1254	323	25.8
Antibiotic	976	6.8	29	74.4	976	335	34.3
Dietary supplement	176	1.3	5	12.8	165	163	98.8
Insecticide	148	1.1	6	15.4	140	2	1.4
Miscellaneous	108	0.76	15	38.5	60	34	56.7
Disinfectant	62	0.43	5	12.8	4	4	100.0
Electrolytes	40	0.29	3	7.7	37	41	2.7
Hormone	32	0.22	8	20.5	32	0	0.0
Anti-inflammatory	24	0.17	5	12.8	24	24	100.0
Analgesic	12	0.08	2	5.1	0	-----	-----
Antifungal	7	0.05	1	2.6	7	7	100.0
Antihistamine	5	0.04	5	12.8	0	-----	-----
Total	14310	-----	-----	-----	14165	6394	45.1

[1] A total of 14310 treatments were recorded.
[2] A total of 39 farms recorded information on treatments

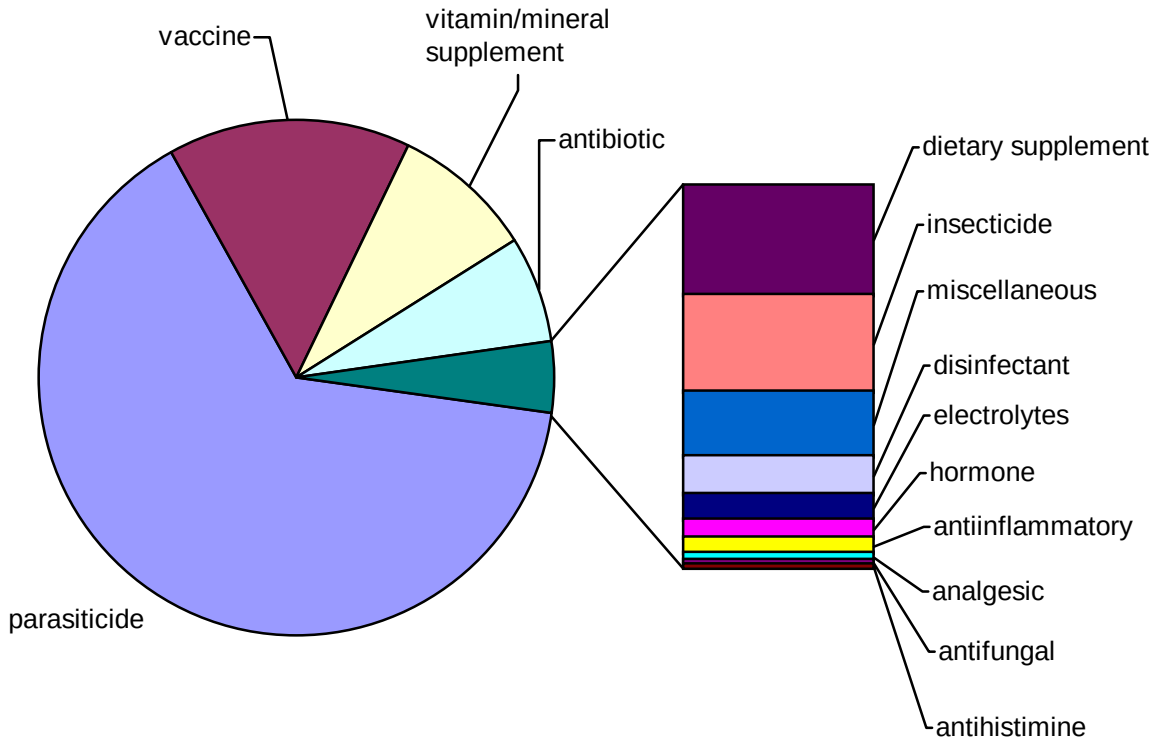

Figure 3. Types of products administered by 39 Virginia sheep producers who recorded animal treatment for 4 months.

Treatments per Sheep

I. Results

During the four-month recording period the median number of treatments per sheep per month was 1.5 (range 0-5.1). This results in a median number of treatments per 100 sheep per month of 150 (range 7-505).

None of the variables tested was associated with a difference ($p>0.10$) in the number of treatments per 100 sheep per month (Tables 17 and 18).

The number of antibiotics, parasiticides, vaccines and vitamin/mineral supplements administered per 100 sheep per month was calculated for each producer (Tables 19-23). No differences were found in the number of treatments per 100 sheep per month for the various flock sizes (Table 19). Producers who owned only commercial crossbred sheep used more parasiticides per 100 sheep per month than producers who owned both purebred and commercial sheep (Table 20). Producers who had a valid veterinary-client-patient relationship used more vaccines and more vitamin/mineral supplements per 100 sheep per month than those who did not have a valid veterinary-client-patient relationship (Table 21). Producers who kept written records on all animals treated with drugs also used more vaccines and vitamin/mineral supplements per 100 sheep per month than those who did not keep such records (Table 22). Additionally, producers who used drugs in an extra-label fashion used more vaccines per 100 sheep per month than those who did not use drugs in an extra-label fashion (Table 23).

The number of condition types treated per 100 sheep per month was calculated for respiratory, reproductive, miscellaneous and musculoskeletal conditions for each producer (Table 24-28). No differences ($p>0.10$) were found in the mean number of treatments per 100 sheep per month for any of the conditions tested for the following variables: flock size, production type, valid veterinary-client-patient relationship, maintenance of written records and use of drugs in an extra-label fashion.

II. Discussion

All calculations in this section were based on the number of sheep present on the farm at the time of the interview. Many ewes lambed during the course of the study and changes in the number of sheep on participants' farms are not reflected in these numbers.

Therefore, the number of treatments per 100 sheep per month reported in this study is likely an overestimate of the actual number of treatments administered to individual sheep.

The median number of treatments recorded per sheep per month of the study was 1.5. The number of products administered is expected to be higher during lambing season than at other times of the year due to the increased number of animals on the farm as well as increased number of reproductive problems among pregnant ewes and sickness in lambs. Thirty-three producers owned ewes that lambed from March to May; these producers were participating in the study during the time of year when treatment of their flocks would be most likely to occur. Additionally, this study took place during warm months, when sheep were grazing and, therefore, being dewormed at an increased frequency. Parasiticides accounted for 9272 (64.8%) of the pharmaceuticals and biologics given over the course of the study. This number would most likely be smaller if the study had taken place during cool months when sheep grazed less and were dewormed less frequently. Therefore, the number of treatments per sheep per month observed in this study is most likely higher than what would be observed at other times of the year due to the season in which the study took place.

For this section of the study, management factors included interview responses regarding maintenance of written records of animal treatment, establishment of a valid veterinary-client-patient relationship, use of drugs in an extra-label fashion, utilization of a deworming protocol, use of feed additives, and the routine administration of reproductive, respiratory and clostridial vaccinations. Overall, management factors did not influence the number of treatments per 100 sheep per month, the number of product types administered per 100 sheep per month or the number of conditions treated per 100 sheep per month. This could be partially due to the small sample size, as well as to the similarity of management practices of producers that were enrolled in the study. The fact that production type influenced the number of parasiticides administered per 100 sheep per month may be due to the preferential breeding season of breeds associated with specific production types as well as to the limited time period of the study. Producers who reported using drugs in an extra-label manner administered more vaccines per 100 sheep per month, as did producers who maintained written records of individual animal

treatments. Additionally, producers who maintained written records on animal treatment administered more vitamin/mineral supplements per 100 sheep per month. Shepherds who keep written records may adhere to a stricter schedule and not forget to vaccinate and supplement at the appropriate time intervals, or because of better record keeping, these producers may have more accurately reported vaccine and supplement usage during the study. The use of drugs in an extra-label manner and the maintenance of written records may also be influenced by a producer's involvement in a valid veterinary-client-patient relationship. Producers who reported having established a valid veterinary-client-patient relationship administered more vaccines and more vitamin/mineral supplements per 100 sheep per month; this is expected because of the importance that veterinarians place on disease prevention. Veterinarians may influence a producer's utilization of preventive agents, such as vaccines and supplements, resulting in more of these product types being used by producers who have established a valid veterinary-client-patient relationship.

Table 17. Association of interview responses and the number of treatments per 100 sheep per month[1] by 39 Virginia sheep producers.

Variable	Number of farms	Mean number of treatments per sheep	Median number of treatments per sheep	Range	p-value
Month of enrollment					0.84[2]
March	24	159.2	138	14-505	
April	7	170.8	169	59-317	
May	8	186.5	206	7-302	
Flock size					0.70[3]
1-49	20	173.9	123	23-505	
≥50	19	159.5	169	7-353	
Production type					0.31[2]
Commercial	14	173.2	169.5	14-505	
Purebred	16	207.2	202	101-433	
Both	9	133.8	128	7-353	
Written records kept on individual animal treatments					0.82[3]
Yes	14	161.4	121	7-505	
No	25	170.0	161	14-433	
Valid veterinary-client-patient relationship					0.46[3]
Yes	33	172.8	150	7-505	
No	6	134.7	149.5	14-234	
Drugs used in an extra-label manner					0.90[3]
Yes	34	167.8	149	7-505	
No	5	161.0	202	14-234	
Utilization of a deworming protocol					1.00[4]
Yes	37	165.0	150	7-505	
No	2	167.0	165	28-302	
Feed additives used					0.88[3]
Yes	20	169.7	151	14-505	
No	19	164.0	150	7-353	

[1] The number of treatments per 100 sheep per month was calculated for each producer by dividing the total number of treatments given by that producer during the four-month recording period by the number of sheep present at the time of the interview, multiplying by 100 and dividing by 4.
[2] ANOVA
[3] t-test
[4] Wilcoxon Rank Sum test

Table 18. Association of vaccination practices (as reported in the interview) and number of non-vaccine treatments per 100 sheep per month[1] recorded by 39 Virginia sheep producers.

Variable	Number of farms	Mean number of non-vaccine treatments per sheep	Median number of non-vaccine treatments per sheep	Range	p-value
Routinely vaccinated against reproductive diseases					0.51[2]
Yes	8	173.8	112.0	2.5-465	
No	31	133.1	122.1	7-318.3	
Routinely vaccinated against clostridial diseases					0.70[3]
Yes	37	143.2	120.6	2.5-465	
No	2	110.7	110.7	19.8-201.6	
Routinely vaccinated against respiratory diseases					0.33[4]
Yes	6	103.4	112.7	7-183	
No	33	148.4	120.6	2.5-465	

[1] The number of non-vaccine treatments per 100 sheep per month was calculated for each producer by dividing the total number of treatments made using all products except vaccines by the number of sheep present at the time of the interview, multiplying by 100 and dividing by 4.
[2] Welsh-ANOVA
[3] Wilcoxon Rank Sum test
[4] t-test

Table 19. Association of flock size and the number of product types administered per 100 sheep per month[1] by 39 Virginia sheep producers.

	Flock size		
	1-49	**≥50**	**p-value**
Number of flocks	20	19	
Antibiotics			0.11[2]
Mean	31.1	4.3	
Median	5.4	2.3	
Range	0-313	0-19	
Parasiticides			0.20[3]
Mean	122.1	92.0	
Median	114.5	8.8	
Range	2.5-283.2	0-235.2	
Vaccines			0.27[2]
Mean	28.1	17.9	
Median	28.8	9.25	
Range	0-85.3	0-74	
Vitamin/mineral supplements			0.24[2]
Mean	7.1	9.9	
Median	1.3	2.3	
Range	0-60	0-43.8	

[1] The number of product types per 100 sheep per month was calculated for each producer by dividing the total number of treatments with each product type during the four-month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Wilcoxon Rank Sum test
[3] t-test

Table 20. Association of production type and the number of product types administered per 100 sheep per month[1] by 39 Virginia sheep producers.

	Production type			
	Commercial	**Purebred**	**Both**	**p-value[2]**
Number of flocks	16	9	14	
Antibiotics				0.16
Mean	28.2	4.3	15.3	
Median	4.0	0.0	5.1	
Range	0-313	0-16.8	0-84.5	
Parasiticides				0.03
Mean	139.0	100.8	75.7	
Median	134.0	64.5	79.0	
Range	18-235.3	2.5-283.3	0-172.3	
Vaccines				0.94
Mean	22.0	20.4	26.2	
Median	16.6	16.3	15.8	
Range	0-55	0-65	0-82.3	
Vitamin/mineral supplements				0.96
Mean	7.7	10.7	7.8	
Median	3.3	2.5	1.3	
Range	0-283	0-60	0-43.8	

[1] The number of product types per 100 sheep per month was calculated for each producer by dividing the total number of treatments with each product type during the four-month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Kruskal-Wallis test

Table 21. Association of the establishment of a valid veterinary-client-patient relationship (as reported in the interview) and the number of product types administered per 100 sheep per month[1] by 39 Virginia sheep producers.

		Valid veterinary-client-patient relationship		
		Yes	**No**	**p-value**
Number of producers		33	6	
Antibiotics				0.58[2]
	Mean	18.1	17.7	
	Median	3.5	1.4	
	Range	0-313	0-84.5	
Parasiticides				0.94[3]
	Mean	107.1	109.7	
	Median	111.0	75.8	
	Range	0-283.3	2.5-235.3	
Vaccines				0.02[2]
	Mean	26.8	3.3	
	Median	29.3	0.0	
	Range	0-85.3	0-20	
Vitamin/mineral supplements				0.09[2]
	Mean	9.7	1.6	
	Median	3.3	0.0	
	Range	0-60	0-9.5	

[1] The number of product types per 100 sheep was calculated for each producer by dividing the total number of treatments with each product type during the four-month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Wilcoxon Rank Sum test
[3] t-test

Table 22. Association of the maintenance of written records on animal treatment (as reported during the interview) and product types administered per 100 sheep per month[1] by 39 Virginia sheep producers.

		Written records kept on animal treatment		
		Yes	**No**	**p-value**
Number of producers		34	5	
Antibiotics				0.93[2]
	Mean	17.6	21.3	
	Median	3.3	3.0	
	Range	0-313	0-84.5	
Parasiticides				0.83[3]
	Mean	108.4	101.0	
	Median	110.5	76.5	
	Range	0-283.3	0-256.8	
Vaccines				0.05[2]
	Mean	26.0	4.0	
	Median	24.9	0.0	
	Range	0-85.3	0-74	
Vitamin/mineral supplements				0.03[2]
	Mean	9.7	0.05	
	Median	4.6	0.0	
	Range	0-18	0-60	

[1] The number of product types per 100 sheep per month was calculated for each producer by dividing the total number of treatments with each product type during the four-month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Kruskal-Wallis test
[3] t-test

Table 23. Association of the use of drugs in an extra label fashion (as reported during the interview) and product types administered per 100 sheep per month[1] by 39 Virginia sheep producers.

		Drugs used in an extra-label fashion		
		Yes	**No**	**p-value**
Number of producers		14	25	
Antibiotics				0.39[2]
	Mean	35.5	8.3	
	Median	5.4	3	
	Range	0-313	0-84.5	
Parasiticides				0.72[3]
	Mean	101.7	110.7	
	Median	99.4	111.5	
	Range	0-283.3	2.5-235.3	
Vaccines				0.03[2]
	Mean	35.0	16.6	
	Median	41.6	2.3	
	Range	0-85.3	0-20	
Vitamin/mineral supplements				0.30[2]
	Mean	4.0	10.9	
	Median	1.4	2.3	
	Range	0-60	0-0.3	

[1] The number of product types per 100 sheep per month was calculated for each producer by dividing the total number of treatments with each product type during the four-month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Kruskal-Wallis test
[3] t-test

Table 24. Association of flock size and number of treatments for selected conditions per 100 sheep per month[1] by 39 Virginia sheep producers.

	Flock size		
	1-49	**≥50**	**p-value[2]**
Number of flocks	20	19	
Respiratory			0.56
Mean	3.8	0.8	
Median	0.0	0.0	
Range	0-47.3	0-4.8	
Reproductive			0.57
Mean	18.6	1.6	
Median	0.0	0.3	
Range	0-305	0-12	
Miscellaneous			0.11
Mean	7.4	0.8	
Median	2.0	0.0	
Range	0-50.8	0-4.3	
Musculoskeletal			0.71
Mean	5.9	1.8	
Median	0.0	0.0	
Range	0-39	0-23	

[1] The number of condition types treated per 100 sheep per month was determined for each producer by dividing the total number of treatments given for each condition over the four month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Wilcoxon Rank Sum test

Table 25. Association of production type and the number of treatments for selected conditions per 100 sheep per month[1] for 39 Virginia sheep producers.

	Production type			
	Commercial	**Purebred**	**Both**	**p-value[2]**
Number of flocks	16	9	14	
Respiratory				0.46
Mean	2.2	0.3	4.0	
Median	0.0	0.0	0.0	
Range	0-18.8	0-1.3	0-47.3	
Reproductive				0.20
Mean	20.6	1.1	4.4	
Median	0.9	0.0	0.0	
Range	0-305	0-10	0-42.8	
Miscellaneous				0.83
Mean	4.6	3.6	4.2	
Median	0.1	0.0	0.0	
Range	0-50.8	0-21	0-40.8	
Musculoskeletal				0.56
Mean	3.7	1.3	5.8	
Median	0.0	0.0	0.0	
Range	0-23	0-10.5	0-39	

[1] The number of condition types treated per 100 sheep per month was determined for each producer by dividing the total number of treatments given for each condition over the four month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Kruskal-Wallis test

Table 26. Association of the establishment of a valid veterinary-client-patient relationship (as reported in the interview) and number of treatments for selected conditions per 100 sheep per month[1] by 39 Virginia sheep producers.

	Valid veterinary-client-patient relationship		
	Yes	**No**	**p-value[2]**
Number of producers	33	6	
Respiratory			0.45
Mean	2.7	0.5	
Median	0.0	0.0	
Range	0-47.3	0-3	
Reproductive			0.48
Mean	12.0	0.9	
Median	0.0	0.0	
Range	0-305	0-4.8	
Miscellaneous			0.44
Mean	3.7	6.8	
Median	0.3	0.0	
Range	0-50.8	0-40.8	
Musculoskeletal			0.22
Mean	7.3	10.7	
Median	0.0	1.4	
Range	0-35	0-39	

[1] The number of condition types treated per 100 sheep per month was determined for each producer by dividing the total number of treatments given for each condition over the four month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Wilcoxon Rank Sum test

Table 27. Association of the maintenance of written records of animal treatments (as reported in the interview) and number of treatments for selected conditions per 100 sheep per month[1] by 39 Virginia sheep producers.

	Written records kept on animal treatment		
	Yes	**No**	**p-value[2]**
Number of producers	14	25	
Respiratory			0.14
Mean	5.8	0.5	
Median	0.0	0.0	
Range	0-47.3	0-4.8	
Reproductive			0.54
Mean	25.6	1.7	
Median	0.0	0.3	
Range	0-305	0-12	
Miscellaneous			0.91
Mean	5.9	4.8	
Median	0.1	0.0	
Range	0-21	0-50.8	
Musculoskeletal			0.68
Mean	5.6	3.0	
Median	0.0	0.0	
Range	0-35	0-39	

[1] The number of condition types treated per 100 sheep per month was determined for each producer by dividing the total number of treatments given for each condition over the four month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Wilcoxon Rank Sum test

Table 28. Association of the use of drugs in an extra-label fashion (as reported in the interview) and number of treatments for selected conditions per 100 sheep per month[1] by 39 Virginia sheep producers.

	Drugs used in an extra-label fashion		
	Yes	**No**	**p-value[2]**
Number of producers	34	5	
Respiratory			0.61
Mean	8.7	0.6	
Median	0.0	0.0	
Range	0-47.3	0-3	
Reproductive			0.73
Mean	52.4	1.1	
Median	0.0	0.0	
Range	0-305	0-4.8	
Miscellaneous			0.62
Mean	3.5	8.8	
Median	0.0	0.3	
Range	0-50.8	0-40.8	
Musculoskeletal			0.46
Mean	2.7	12.4	
Median	0.0	0.0	
Range	0-35	0-39	

[1] The number of condition types treated per 100 sheep per month was determined for each producer by dividing the total number of treatments given for each condition over the four month recording period by the number of sheep present on the farm at the time of the interview, multiplying by 100 and dividing by 4.
[2] Wilcoxon Rank Sum test

Cost of Recorded Treatments

I. Results

The cost of treatment was estimated for 13,912 treatment events (Tables 29 and 30). The estimated cost of all treatments over the course of the study was $7,523.78. The estimated mean cost of treatment was $0.54. The most expensive product type were parasiticides, with a mean estimated cost of $0.66 per administration (Table 29). Respiratory conditions were the most expensive condition treated, with an estimated mean cost of $1.09 per treatment (Table 30). Parasite control accounted for the highest total amount spent on treatment.

A total of 2,987 sheep were reported as being owned during the questionnaire phase of the study. This results in an estimated cost of $2.52 per sheep over the four-month recording period, or $0.63 per sheep per month.

II. Discussion

A 1991 study found that cow-calf producers in Tennessee spent approximately $11.63 on medications per cow per year[29]. This number is higher than what was observed for sheep producers in this study. Only $0.63 was spent per sheep per month of the study, resulting in an annual cost of approximately $7.56 per sheep. Because of the increased number of treatments administered during lambing season and the time of the year during which this study took place, it is likely that the amount spent on pharmaceuticals and biologics during this study is higher than what would be observed during other times of the year. The cost of animal treatment observed in this study was an estimated value, using approximate doses and prices from only two livestock supply catalogs. Additionally, the cost of labor and veterinary services was not taken into account. Because of this, the actual cost of animal disease may be different than what was reported in this study. The total cost of treatment was highest for parasiticides, vaccines, antibiotics and vitamin/mineral supplements. This is not surprising since these were the most frequently administered products. Outside of preventive treatments for parasite control and vaccination, diseases of the respiratory system were the most expensive to treat over the course of the study. Specific products used to treat respiratory conditions included Nuflor® and Naxcel® which are more expensive than other available antibiotics, resulting in increased

treatment costs. Prevention of respiratory disease could reduce the cost of curative treatments for sheep producers.

The 1997 United States Agricultural census reported that there were 7.8 million sheep and 99.0 million cattle in the United States[39]. Combining the relatively small sheep population in the United States with the small amount spent on pharmaceuticals to treat sheep supports the view that it is not economically feasible for pharmaceutical companies to develop and label products for use in sheep. The enactment of MUMS will provide financial incentives to pharmaceutical companies to help overcome the economic obstacles of drug approval.

Table 29. Estimated total and mean cost of treatment using different product types.

Product type	Number of administrations	Total cost of treatment with product type ($)	Mean cost of product administration per treatment($)	Minimum cost of product administration per treatment($)	Maximum cost of product administration per treatment($)
Parasiticide	9251	6133.11	0.66	0.04	3.66
Antibiotic	895	455.42	0.51	0.01	3.35
Anti-inflammatory	23	10.72	0.47	0.23	0.91
Electrolytes	37	12.82	0.35	0.07	0.37
Vaccine	2182	711.03	0.33	0.09	4.41
Miscellaneous	31	7.75	0.25	0.01	0.97
Dietary supplement	165	15.60	0.09	0.08	0.63
Hormone	31	2.40	0.08	0.05	0.32
Analgesic	8	0.38	0.05	0.05	0.05
Vitamin/mineral supplement	1253	173.83	0.04	0.01	2.01
Insecticide	36	0.72	0.02	0.02	0.02
Total	13912	7523.78	0.54	0.01	4.41

Table 30. Estimated total and mean cost of treatment for different types of conditions.

Type of condition	Number of treatments	Total cost ($)	Mean cost per treatment ($)	Minimum cost of treatment($)	Maximum cost of treatment($)
Respiratory system	205	223.81	1.09	0.02	3.08
Gastrointestinal system	98	40.45	0.41	0.01	3.20
Miscellaneous condition	136	100.08	0.74	0.01	3.55
Parasite control	9266	6107.55	0.66	0.02	3.66
Musculoskeletal system	164	89.49	0.55	0.05	2.07
Miscellaneous infection	45	11.87	0.26	0.02	0.91
Prevention	22	7.57	0.34	0.07	1.66
Vaccination	2170	707.70	0.33	0.09	4.41
Reproductive system	444	76.92	0.17	<0.01	3.08
Supplementation	1202	144.04	0.12	0.03	0.35
Dietary supplementation	160	14.30	0.09	0.08	0.17
Total	13912	7523.78	0.54	0.01	4.41

Summary

This study was initiated to address the lack of information on the usage of pharmaceuticals and biologics in the sheep industry. Results indicate that the majority of products being administered to sheep are preventive products such as parasiticides, vaccines and vitamin/mineral supplements. Slightly less than half (46.9%) of the treatments made using parasiticides, vitamin/mineral supplements and antibiotics consisted of products approved by the FDA for use in sheep. Because treatment with these products accounted for a large portion of the total treatments administered, sheep in the study may have been given some products for which little research concerning withdrawal time and residue occurrence in sheep had been conducted. This is of concern since all of the producers who took part in this study marketed their sheep for meat. Despite the fact that 84.6% of participants had established a valid veterinary-client-patient relationship, only 67.6% of those who used drugs in an extra-label fashion indicated that it was done so under a veterinarian's direction. An additional area of concern is that few producers reported keeping records on individual animals treated with drugs. Of those that did keep records, only one recorded the date that the animal could be marketed and no producers recorded the withdrawal time of the drug that was used, so it is possible that animals in this study could be slaughtered before the appropriate withdrawal time had been observed.

Studies collecting data on residue violations have observed that antibiotics resulted in the most frequent residue violations and that most violative residues resulted from products purchased from a feed store or veterinarian. Most products resulting in violations were administered by the owner of the animal and the most common causes of violations were failure to maintain adequate records or follow the appropriate withdrawal time[25,26]. Although only 6.8% of the treatments recorded during this study were with antibiotics, it was found that more than 98% of the treatments were made by the owner of the animal and the majority of producers purchased pharmaceuticals from a feed store or veterinarian. However, because the average number of treatments administered per sheep was low and the market for sheep in the United

States is small, the sheep industry may contribute little to the overall problem of residue occurrence when compared to larger animal production industries.

In addition to preventive treatments, curative treatments occurred over the course of the study. Conditions treated included respiratory conditions, reproductive conditions, miscellaneous conditions and musculoskeletal conditions, suggesting that approved products for the treatment of these types of conditions are needed for the sheep industry. It should also be noted that 15.4% of producers administer respiratory vaccines to their sheep, however there are no respiratory vaccines that are labeled for use in sheep. This suggests that research should be conducted to determine the safety and efficacy of these products in sheep. The sources of information that producers use to make treatment decisions for their flock were varied. Most of the producers indicated that veterinarians played a role in determining vaccine and deworming practices. However, additional sources of information were used by all of the producers, with other producers frequently cited as a source of information. This suggests that there is a lack of veterinarians and other professionals that are available to sheep producers or that professionals who are available for assistance are not viewed by producers as being affordable or knowledgeable in sheep production. Although 84.6% of producers reported having established a valid veterinary-client-patient relationship, a veterinarian gave less than 2% of all treatments administered over the course of the study. Producers often stated during interviews that the economic value of an individual sheep did not justify the expense of veterinary services. With a lack of knowledgeable professionals and the expense involved in obtaining the service of a veterinarian, producers were often forced to make treatment decisions using other sources of information.

Results of this study provide a detailed picture of a section of sheep production practices in Virginia. The "average" flock in this study consists of approximately 75 sheep, both pure and crossbred. Ewes lamb in multiple seasons and lambs are sold to a variety of markets: meat, wool, breeding stock, and club lambs. The health protocols of most flocks have been influenced by a veterinarian, but the cost of veterinary services is too high and the availability of veterinarians with extensive sheep knowledge is too limited for veterinary services to be used on a regular basis. Instead, many producers turn to other sources of information such as textbooks,

extension services or other sheep producers. The flock is routinely vaccinated for *Clostridium perfringens* types C and D and *Clostridia tetani* and is also routinely dewormed during the warmer months. Conditions requiring treatment within the flock include internal parasites, foot rot and pneumonia. With a small number of drugs approved for use in sheep so many of the treatments administered to the flock are administered in an extra-label manner. Sheep in the flock receive an average of 1.7 treatments per month. Little money is spent on pharmaceuticals used in treatment: only 63 cents per sheep per month. Overall, the flock is healthy, with most of the treatments that are administered to the sheep being of a preventive rather than a curative nature.

References Cited

1. Adams JB. Assuring a residue-free food supply: Milk. *J Am Vet Med Assoc*;202:1723-1725.
2. Lautner B. Assuring a residue-free food supply: Pork. *J Am Vet Med Assoc* 1993;202:1727-1729.
3. Wilkes D. Assuring a residue-free food supply: Beef. *J Am Vet Med Assoc* 1993;202:1725-1727.
4. Friedlander LG, Brynes SD, Fernandez AH. The human food safety evaluation of new animal drugs. *Vet Clin North Am Food Anim Pract* 1999;15:1-11, vii.
5. DuPont HL, Steele JH. Use of Antimicrobial Agents in Animal Feeds: Implications for Human Health. *Reviews of Infectious Diseases* 1987;9:447-460.
6. Paige JC. The issues of residues and human health. *J Am Vet Med Assoc* 1998;213:1735-6.
7. Paige JC, Tollefson L, Miller M. Public health impact on drug residues in animal tissues. *Vet Hum Toxicol* 1997;39:162-9.
8. Sundberg P. Food Safety: Antimicrobial Residues. *Compendium* 2000;22:S118-S123.
9. Teske RH. Chemical residues in food. *J Am Vet Med Assoc* 1992;201:253-6.
10. Cerniglia CE, Kotarski S. Evaluation of veterinary drug residues in food for their potential to affect human intestinal microflora. *Regul Toxicol Pharmacol* 1999;29:238-61.
11. Sundlof SF. Legal and responsible drug use in the cattle industry: The Animal Drug Availability Act. *Veterinary Medicine* 1998:681-684.
12. Sundlof SF. Legal and responsible drug use in the cattle industry: Extra-label use. *Veterinary Medicine* 1998:673-684.
13. Extra-label use--Questions and Answers. *FDA Veterinarian* 1997;12.
14. Curry-Galvin E. Extra-label rules: the final outcome. *http://www.avma.org/onlnews/javma/jan97/s010197c.html* 1997.
15. Upson DW. Privileges and responsibilities relating to extra-label drug use. *J Am Vet Med Assoc*;192:242-246.
16. Proposals to Increase the Legal Availability of Animal Drugs for Minor Species and Minor Uses. *http://www.fda.gov/cvm/index/mums/mumsprop.htm* 1998.
17. Minor Use and Minor Species Animal Health Act: http://www.avma.org/scienact/mums/default.asp.
18. Lee MH, Lee HJ, Ryu PD. Public health risks: chemical and antibiotic residues. *Asian Australasian Journal of Animal Sciences* 2001;14:402-413.
19. Cordle MK. USDA regulation of residues in meat and poultry products. *J Anim Sci* 1988;66:413-33.
20. Paige JC, Tollefson L, Miller MA. Health implications of residues of veterinary drugs and chemicals in animal tissues. *Vet Clin North Am Food Anim Pract* 1999;15:31-43, viii.
21. Woodward KN. Hypersensitivity in humans and exposure to veterinary drugs. *Vet Hum Toxicol* 1991;33:168-72.

22. Council NR. *The Use of Drugs in Food Animals: Benefits and Risks.* Washington, D.C.: National Academy of Science, 1999.
23. Franco DA, Webb J, Taylor CE. Antibiotic and Sulfonamide Residues in Meat: Implications for Human Health. *Journal of Food Protection* 1990;53:178-185.
24. Young HK. Do Nonclinical Uses of Antibiotics Make a Difference. *Infection Control and Hospital Epidemiology* 1994;15:484-487.
25. Van Dresser WR, Wilckey JR. Drug Residues in Food Animals. *J Am Vet Med Assoc* 1989;194:1700-1710.
26. Paige JC. Analysis of Illegal Residues in Meat and Poultry. *FDA Veterinarian* 1993;8:5-6.
27. Reference of 1996 U.S. Sheep Health and Management Practices. *United States Department of Agriculture. National Animal Health Monitorring System* 1996.
28. de la Concha-Bermejillo A, Anderson NV, Bretzlaff K, et al. Overview of Diseases and Drug Needs for Sheep and Goats. Veterinarians' and Producers' Perspectives. *Vet Human Toxicol* 1998;40:7-12.
29. New JCJ. Costs of veterinary services and vaccine/drugs used for prevention and treatment of diseases in 60 Tennessee cow-calf operations (1987-1988). *J Am Vet Med Assoc* 1991;198:1334-1340.
30. Judicious Use of Antimicrobials for Beef Cattle Veterinarians. *http://www.avma.org/scienact/jtua/cattle/jtuabeef.asp*.
31. *Compendium of Veterinary Products*. 4th ed. Port Huron, MI: Bayley, Adrian J., 1997.
32. Microsoft. Excel. 9 ed, 1999.
33. SAS. JMP. 4.0 ed. Pacific Grove, Ca, 2001.
34. Jeffers Catalog, Summer 2002.
35. PBS Animal Health, March/May 2002.
36. Agriculture Census for Virginia. *http://govinfo.library.orst.edu/cgi-bin/ag-list?17-state.vas* 1997.
37. Umberger SH. Virginia Cooperative Extension Sheep Management Schedule. *http://www.ext.vt.edu/pubs/sheep/410-365/410-365.html* 1996.
38. American Medical Association. Report 1 of the Council on Scientific Affairs. Pharmaceutical Expiration Dates.: http://www.ama-assn.org/ama/pub/print/article/2036-5073.html.
39. Agricultural Census for the United States. *http://govinfo.library.orst.edu/cgi-bin/ag-list?17-state.usa* 1997.

Appendix 1. Drugs approved by the FDA for use in sheep.

Antibiotics

- Ceftiofur
- Erythromycin
- Neomycin
- Oxytetracycline/chlortetracycline (feed additive)
- Oxytetracycline
- Oxytetracylcine/Polymixin B ophthalmic ointment
- Penicillin G Procaine

Parasiticides

- Albendazole
- Ivermectin liquid
- Levamisole oral bolus
- Thiabendazole oral paste
- Thiabendazole pre-mix

Other

- Neostigmine

Hormones

- Follicle stimulating hormone (injectable)
- Oxytocin
- Pituitary luteinizing hormone injectable
- Zeranol implant

Vitamin/mineral supplements

- Selenium-Vitamin E

Anesthetics

- Proparacaine (topical ophthalmic anesthetic)

Coccidiostats

- Decoquinate (feed additive)
- Lasalocid

Appendix 2. Introductory letter and questionnaire sent to 274 Virginia sheep producers.

The Virginia Maryland Regional College of Veterinary Medicine and Virginia Cooperative Extension are conducting a study to collect information concerning conditions in sheep that require medical treatment and the drugs, vaccines, and medicinals used in sheep production within the Commonwealth of Virginia. We are seeking volunteers from across the state to provide us with this information. The information we receive will be compiled confidentially and all flock information will be summarized. The summary will provide us information to develop a quality management program for the sheep producer. This information will also identify pharmaceutical agents that should be investigated for minor species usage under FDA guidelines.

If you decide to enroll in the study:

1. One of the investigators will visit your flock to obtain information concerning flock management and current usage of pharmaceuticals, medicinals, and vaccines.
2. A card will be left for the owner/manager to record drug usage, frequency and the condition being treated. Information will be collected in two week increments of time.
3. At the end of two weeks, the manager will receive a new card along with a stamped envelope to return the completed card. Information will be collected for four months.

At the end of the study each participant will receive a detailed description of drug usage in their flock along with a summary of the findings of the study. This information will be useful to the owner in helping to manage medication inventory and usage.

Please fill out the accompanying information page and return it to us in the envelope provided. Thank you very much for your time and consideration in participating in this study.

Katie Rorrer
Kevin Pelzer DVM, MPVM
Francois Elvinger DVM, PhD
Scott Greiner PhD

☐ Please consider me for the study.

☐ I am not interested in participating at this time.

Please complete the following information and make corrections to your address even if you are not interested in participating in the study. When finished, return to us in the envelope provided.

1. Number of animals in your flock. _____
2. When do your ewes lamb? _____
3. Predominant breed within your flock. _____

Appendix 3. Questionnaire used during interviews of 58 Virginia sheep producers.

General Information

Producer Name _____
Address_____
_____
_____
Phone_____
Best time to be reached _____
Email _____

1. How long have you been in the sheep business?

   a. 0-5 years
   b. 6-10 years
   c. 11-20 years
   d. 20+ years

2. What breed of sheep do you own (please circle all that apply)?

Dorset	_____	Crosses	_____
Suffolk	_____	Border Leister	_____
Hampshire	_____	other (please specify)	_____
Finnsheep	_____		
Polypay	_____		

3. When do your ewes lamb (please check all that apply)?

fall (Sept-Nov)	_____
winter (Dec-Feb)	_____
spring (March-May)	_____
other (please specify)	_____

4. Do you market lambs for meat? _____
   wool? _____
   club lambs _____
   breeding stock? _____
   other (please specify) _____

5. How many lambs do you sell each year? _____
6. Are all animals in the flock identified? Y N
7. Which of the following methods do you use to identify animals (please check all that apply)?

eartag	Y	N
tattoo	Y	N
ear notch	Y	N
other (please specify)	Y	N

8. On average, outside of routine vaccination and Deworming, how many treatments are done per month? _____

9. a. Do you keep written records of individual animals treated with drugs? Y N

b. If yes, which of the following is recorded:

animal ID	Y	N
drug administered	Y	N
amount of drug administered	Y	N
route of administration	Y	N
withdrawal time of the drug used	Y	N
date the animal can be shipped	Y	N

Medications

10. Do you purchase medications from the following (please check all that apply)?

veterinarian	_____
feed store	_____
catalog	_____
other (please specify)	_____

11. How many people administer medications on your farm? _____

12. a. Do you use the following kinds of needles (please check all that apply)?

disposable-single use	_____
disposable-multiple use	_____
re-usable multiple use	_____

b. If you use disposable-multiple use needles, how are they re-used (i.e. are they used to treat multiple animals with the same drug or are they used to give one animal multiple injections or different drugs)?

13. Which sites are used for intramuscular (IM) injections (please check all that apply)?

top of hip _____
hind leg _____
neck _____
other (please specify) _____

14. Which sites are used for subcutaneous (SQ) injections (please check all that apply)?

neck _____
under the elbow _____
over the ribs _____
behind the shoulder _____
other (please specify) _____

15. How do you dispose of the following?

needles _____
syringes _____
drug bottles _____

16. a. Drugs are used in an extra-label fashion if the drug is used in a species not listed on the bottle label, for a disease condition not listed on the bottle label, the dosage given is different than listed on the bottle label, or the route of administration is different than listed on the bottle label. Do you use any drugs in an extra-label fashion? Y____ N_____

b. If you use drugs in an extra-label fashion, is it under the direction of your veterinarian? Y_____ N_____

17. Which of the following do you use for information about drug use and treatment decisions for your flock (please check all that apply)?

extension agents or other extension services _____
feed salesman _____
internet _____
magazine/trade journal _____
other producers _____
veterinarian _____
other (could include textbooks or sheep industry handbook; please specify what other sources you use) _____

Treatments

18. A valid veterinary-client-patient relationship exists when a veterinarian has examined and diagnosed the disease condition or has been involved with an operation to the extent that he/she is very aware of the conditions that exist on the farm and can diagnose "over the phone." Do you have a valid veterinary-client-patient relationship with one or more veterinarians? Y____ N____

19. What percentage of diagnoses are made by the following

owner	_____
manager	_____
veterinarian	_____
extension agent/services	_____
other (please specify)	_____

20. What percentage of treatment decisions are made by the following

owner	_____
manager	_____
veterinarian	_____
extension agent/services	_____
other (please specify)	_____

21. The following are instructions for filling out the table on the next page. Circle yes or no to indicate if you have seen the condition in your flock in the past two years. If you have, circle yes or no to indicate if a veterinarian was called for assistance. Circle yes or no to indicate if you have a standard treatment for the condition. If you do have a standard treatment for the condition, place a check mark in the appropriate box to indicate who planned the treatment.

				If you have a standard treatment for the condition, who helped plan it?			
	Have you seen the condition in the past 2 years?	Do you call a vet for assistance with this condition?	Do you have a standard treatment for this condition?	owner/ manager	vet	extension agent/ services	other (please specify)
difficult lambing	Y N	Y N	Y N				
retained placentas	Y N	Y N	Y N				
ketosis	Y N	Y N	Y N				
off feed	Y N	Y N	Y N				
diarrhea/scours	Y N	Y N	Y N				
pneumonia	Y N	Y N	Y N				
mastitis	Y N	Y N	Y N				
lameness	Y N	Y N	Y N				
foot rot	Y N	Y N	Y N				
pink eye	Y N	Y N	Y N				
internal parasites	Y N	Y N	Y N				
external parasites	Y N	Y N	Y N				
polio	Y N	Y N	Y N				
pregnancy toxemia	Y N	Y N	Y N				
other (please specify)	Y N	Y N	Y N				

Disease Prevention

22. a. Which of the following do you vaccinate for (please circle yes or no, indicate the dosage used and place a check mark in the appropriate box to indicate the time of administration).

		dosage	pre-breeding	pre-lambing	weaning	other (please specify)
scours	Y N					
chlamydia	Y N					
campylobacter	Y N					
brucella	Y N					
clostridium	Y N					
soremouth	Y N					
respiratory diseases	Y N					
tetanus	Y N					
other (please specify)	Y N					

b. Do you administer injectable Vit E/Selenium? Y N

c. If you answered yes to 22b, at what time do you administer Vit E/Selenium?

pre-breeding _____

pre-lambing _____

weaning _____

other (please specify) _____

23. Who of the following helped plan your vaccination protocol (please check all that apply)?

extension agent/services _____
veterinarian _____
other (please specify) _____

24. a. Do you have a deworming protocol? Y_____ N_____

b. If you answered yes to 24a, briefly outline your Deworming protocol, including dosage used, below.

c. If you answered yes to 24a, who helped plan your deworming protocol?

extension agent/services _____
veterinarian _____
other (please specify) _____

Lambing

25. What percentage of your lambs are born outside? _____
_____

26. a. Which of the following treatments do lambs routinely receive after birth (please check all that apply)?

navel dipping _____
Vit E/Selenium injections _____
nutritional supplementation_____
antibiotic injection _____
other (please specify) _____

b. If lambs routinely receive antibiotic injections after birth, which antibiotic is used?

_____

27. Which of the following feed additives do you use (please check all that apply)?

Bovatec _____
Rumensin _____
Aureomycin _____
Amprolium crumbles (Corid) _____
MGA _____
Decox _____
other (please specify) _____

Appendix 4. Treatment cards left with producers at the time of the interview.

Treatment Record Sheet		Producer:			Week Dates:	
Animal ID	Date	Product	How Much?	How/Where Given?	By Whom?	Why?

Vita

Rebecca "Katie" Rorrer was born to Rebecca Kidwell and Michael Rorrer in Richmond, VA in 1977. She moved to Blacksburg with her mother and older brother, Chris, in 1985. After graduating from Blacksburg High School she spent time in Boone, NC and Vinton, VA before completing her B.S. in Biochemistry at Virginia Tech in 1999. After graduation, Katie worked at a small animal veterinary practice and, later, at a research facility before deciding to continue her education by enrollment in the Master's program in Veterinary Medical Science. During the past two years she has also worked as a research technician at CropTech Development Corporation in Blacksburg. In her spare time Katie enjoys competing in flyball and agility with her two dogs, as well as hiking, camping and canoeing.