

# Applications of livestock in biomedical research

## Abstract

Human beings used livestock for a wide variety of purposes such as for meat, milk, transportation and in researches including biomedical research. When a new technique, products or drugs developed for humans and animals, researcher found it unethical to use it directly to humans. So they conduct research on animals to know the safety and efficacy of the newly developed product before it is being introduced into markets. The use of animals is indispensable esp. in the field of physiology, nutrition, pathology, pharmacology, surgery and biotechnology. Animal experiments used in several biomedical research, product testing, developing new treatments or vaccines for diseases, medical research, safety testing of non-medical products used in industry, agriculture and also for developing new diagnostic methods. Single cell lines and tissue culture are used by researchers to study the biological processes but testing on mammals is essential because they are close to humans in evolutionary terms. Animal research can't be replaced with any other computer models or tissue culture because the complex interaction between cells, tissues, organs, organ systems, organisms and environment can't be studied in any other ways.

**Keywords:** livestock, testing, biomedical, models

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## Introduction

Animal testing/ in vivo testing/ vivisection mean experiments that involve dissection of live animals. The history of animal testing begins in the 20<sup>th</sup> century when Galen, a Roman physician dissected pigs and goats and he is known as the father of animal testing. In 1880, Louis Pasteur demonstrated his germ theory of disease by infecting the sheep with anthrax organism. Later a number of animals like guinea pigs, dogs, equines etc were used in different research purposes and hence it proved that the animals were used repeatedly in the history of biomedical research. Nowadays animals are used in different disciplines such as in pure research, applied research, xeno-transplantation, toxicology testing, drugs testing, cosmetic testing and in education. Scientists rely on animal models to know the pathogenesis of diseases and to develop treatment protocols. Not only good nutrition and sanitation prevents the disease, because in modern time more than infectious cause, a number of people die due to heart problems and cancers. In such a scenario testing on animals like pigs, sheeps etc were found helpful to get an answer for a number of biomedical questions. Since the use of animals in studying various biologies is inseparable in the modern history, several arguments and debates arise for the use of animals in research on the ethical basis.

## Use of livestock in different areas of biomedical research

Animal models have been most important for advancing the knowledge in different biomedical fields. The use of different livestock like cattle, sheep, goats and pigs in scientific studies helps to improve the life of humans, animals and the environment. Approximately 90% of Nobel prizes winning researches in Physiology and Medicine use different animal models in the research. Many species of animals ranging from insects, nematodes to non human primates and sometimes genetically modified species were also been used in biomedical research. Despite the laboratory rodents contribute much for the biomedical research, there are certain limitations like difference in organ size, life span, breeding, physiology, metabolic and behavior patterns,<sup>1</sup> whereas livestock (cattle, sheep, goat and pig) share common anatomy and physiology to humans. Moreover the domestic animals have certain evolved phenotypic traits like body

pigmentation, locomotion pattern, behavior and metabolic traits which make these animals a well established model for the study of various genetic disorders of humans.<sup>2</sup> In-addition to these, the whole genome sequencing of cattle, sheep, goat, pig and the genetically engineered livestock made these animals more significant in biomedical studies. Many genetic, metabolic and infectious disease pathogenesis were studied in farm animals due to their clinical, pathological and biochemical similarities to human diseases.<sup>3</sup> Genetically engineered livestock also found significant for all kind of biomedical studies like storage disease, bleeding disorders, myocardial diseases etc.<sup>1</sup> These genetically engineered animals like sheep and pigs have a natural predisposition for certain human genetic diseases, and they are widely used. A number of nutritional research like porcine model for obesity and metabolic syndrome, bovine model for fat synthesis and various other nutritional parameter studies are also been pinned with livestock species. As per 2013 census by the U.S. Department of Agriculture (USDA), 880,000 animals were used in USDA-regulated research and teaching activities; 11% animals accounted are pigs, sheep, and other farm animals.<sup>4</sup> In-addition to advances in genomics, stem cell research, therapeutic cloning, surgical techniques and procedures and biotechnology all offer speculations in eliminating non-treatable infectious diseases like AIDS and hepatitis, cancer, and for re-growing damaged spinal cord nerves to reverse paralysis. The use of animal models allows toxicologists to develop fundamental knowledge necessary to the understanding of chemical toxicity and protection of humans, animals, and the environment from toxic levels of natural-as well as man-made—exposures.<sup>5</sup>

## Cattle

Cattle is considered as best model for studies on reproductive immunology and placental biology. They are used mainly to study the female reproduction conditions like abortions, pregnancy complications because they have reproductive cycles similar to humans. Those genetically engineered cattle are best models for study of embryonic loss in humans and other species because of their placentation features. Pregnancy complications in cattle also occur due to abnormal gene expression in trophoblast similar to humans where foetal loss occur due to expression of gene like oxidative stress and hypoxia, apoptosis etc.<sup>6</sup>

## Goats and sheep

Goats and sheep are considered as best models for studying cardiac and respiratory systems respectively. Goats esp transgenic goats were used as a model for a sustained atrial fibrillation studies.<sup>7</sup> They were also developed as a model in orthopedic studies, where the anatomy of goats similar to humans.<sup>8</sup> Goats were also used to study certain cancerous conditions like adrenocortical neoplasms and malignant melanoma.<sup>9</sup> The respiratory physiology of sheep is similar to humans, which made it a suitable model in asthma research, pre natal respiratory distress syndrome and neonatal respiratory syncytial virus.<sup>10,11</sup> In addition to cardiovascular studies, sheep are found as suitable models for studying nutrition and also for female fertility.<sup>12</sup> These animals were also used in biotechnology for monoclonal antibody production. Use of pigs as in biomedical research is an advancing field esp in cardiovascular studies. Certain cardiovascular conditions like atherosclerosis, heart failure, abdominal aortic aneurysm, and pacemaker induced atrial fibrillation etc.<sup>13</sup> Xeno transplants using implanted pig pacemakers and insulin secreting cells are latest trends in biomedical research. Also pigs are used for studying skin grafts and reconstructive surgery. Many human genetic disorders like Alzheimer's disease, Parkinson's disease, Huntington's disease Amyotrophic lateral sclerosis etc were studied in genetically engineered pig models.<sup>14</sup> Minipigs have several advantages over rodents in terms of their similarity to human organ systems esp cardiovascular system, immunological similarities are well characterized than the non human primates. Miniature swine breeds are nowadays widely used in safety assessments of new therapeutic compounds given through different routes of exposure as well as in models for human diseases such as diabetes, heart disease, and various skin conditions.

## Importance of livestock in toxicity studies

As part of regulatory requirements the necessity of toxicity tests for all toxic substances and chemicals to preserve current levels of human health and environmental protection is required. To study the possible adverse effects of a substance on human health, environment and wildlife, large numbers of fish, rodents and smaller numbers of birds and amphibians, are used to test industrial and agrochemicals for their toxicity to wildlife populations.<sup>15</sup> In toxicity studies miniature swine breeds are used in pharmacological and preclinical safety testing such as repeat dose, single-dose, teratology, fertility assessments; and absorption, distribution, metabolism, and excretion studies.<sup>16</sup> The use of same dose, route devices and same moments of embryonic developments as in humans, made the miniature pig as suitable model for various types of general and reproductive toxicity studies. Some claims the use of minipigs as only non rodent species and some as second non rodent species.

## Animal ethics

Under the rules of Animal welfare those who were engaged in biomedical research using experimental animals should be registered with CPCSEA (Committee for the Purpose of Control and Supervision of experiments on Animals). To aim the implementation of Good Laboratory Practices, the CPCSEA brought certain mandates while conducting biomedical and behavioral research and testing of new products. Animals housing, care, breeding, management, environment, carcass disposal, biosecurity and disaster management etc. should be considered. Since these animals are source of many zoonotic pathogens, the committee carefully evaluates the adequacy

of vehicles, transport caging, and animal restraint (physical and chemical) for capacity to provide secure transport of the animals to the laboratory facilities and the environment of livestock housed in laboratory settings. The standard operating procedures like restraining methods, castration, animal environment guide like temperature (61–81°F) and humidity ranges (30%–70%) as well as fresh air changes (10–15 per hour) were properly invigilated. Moreover special considerations should be given for those experiments which include the use of biohazard materials, genetically engineered and cloned animals.<sup>17</sup> The staff members conducting such research projects involving hazardous materials should safeguard themselves and select appropriate facilities and equipments and well trained for appreciating the signs of illness, injury, dead and normal animal wise. The guiding principles of animal welfare are the so-called 'three Rs', refinement, reduction and replacement. This means to reduce the sufferings/pain given to animals, decrease the number of animals used in the experiment and also use replacement techniques by using non animal alternatives. This 3R principle is found applicable for genetically modified laboratory animal species which arise a controversy. Although following the third R principle was found difficult, because there is not better replacement to whole animal experiment, all these 3R principles aims the welfare of animals used in research. Thus researches which are highly benefited with low suffering to animals are generally acceptable.

## Conclusion

A research should be relevant one for the health and benefits of humans and animals and most of the animals used in experiments are for medical research esp for preliminary studies. Developments in the treatment of diabetes, cancer and xeno transplants, amongst others, have been made possible through the use of livestock in scientific research. The use of livestock models in areas of physiology, surgery, biomedical and reproductive technologies have gained importance over the last 25 years. Comparatively, similar organ size and functions made farm animals significant one in biomedical research. However, high cost, labour problems and huddles in genetically engineered livestock are the main constrain in using livestock models. The majority of the scientific community and public consider that the benefits to human life have been provided by the use of animals in research. Thus throughout the world people enjoy the benefits of use of animals in biomedical research. Although certain methods like tissue cultures, computer based techniques are generally used in addition to animal studies, and do not replace them, the results from different methods when yield same result it become more beneficial. By reducing the number of animals used and by providing better care and management, a better scientific advances can be made by use of livestock in biomedical research.

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## Conflicts of interest

The author declares that there are no conflicts of interest.

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