Electricity loadshedding and its implications on Animal Welfare in research animal facilities in South Africa

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Abstract

Loadshedding is a deliberate and temporary interruption of electricity supply intended to reduce the demand for electricity during periods of high demand. While loadshedding affects various sectors of the economy, its impact on Research Animal Facilities (RAF) is particularly concerning and this has not been systematically reviewed.

We discuss the implications of loadshedding on Animal Health and Welfare, the quality of experimental data and compliance with RAF regulatory requirements. RAF are designed for the housing laboratory animals that are being used in research that benefits humans, animals and the environment. Scientific data emanating from these facilities needs to be credible and the housing environment should be maintained constantly. Laboratory animals may experience stress when there is disruption to the environmental conditions caused by electricity supply interruptions to the equipment used to maintain a stable and constant facility environment. Constant environmental parameters are essential for maintaining a comfortable working environment for personnel working in the facility as well.

Keywords: Animal Welfare, loadshedding, research animal facility, electricity and environmental housing

Introduction

A RAF is a specially designed building with a controlled internal environment for the housing and maintenance of laboratory animals used for scientific research and teaching purposes. A constantly stable environment is a cornerstone for good Animal Welfare and the integrity of research data. The equipment required to maintain a constant environment is highly dependent on a stable electricity supply. Disruptions caused to the electricity supply can lead to rapid changes in environmental conditions and subsequent stress is caused to laboratory animals.

Stressors confronting laboratory animals fall into two general categories:

- Stressors associated with experimental procedures.
- Stressors associated with husbandry practices[1] with experimental procedures given much scrutiny on ethical approval. Inadequately designed housing environments can induce stress from unstable environmental parameters from sources such as ventilation systems and equipment.[2] Stress alleviation should thus not only be for the purposes of getting ethical approval but also to ensure the research is reputable. To ensure that valid reproducible results are obtained from animal experiments and the minimum number of animals are used, it begins with ensuring that a constant RAF environment is maintained.

In South Africa and most African countries it is increasingly becoming very difficult to maintain a constant animal housing environment due to problems brought about by electricity loadshedding.

Loadshedding is a deliberate and temporary interruption of electricity supply to certain areas on a rotational basis with the intention to reduce the demand for electricity during periods of high electricity demands.[3] In South Africa loadshedding periods vary from anytime between one to six hours or more. The Electricity Supply Commission (ESCOM) of South Africa was established in 1923 with the mandate to efficiently supply electricity in a sustainable way that meets future electricity demands by customers.[4] In 1994, the national government prioritised the development of previously disadvantaged communities,[5] which led to the passing of the 'ESCOM Amendment Act No. 126 of 1998'. The shift in focus by the ESCOM was aimed at providing low-cost electricity to previously disadvantaged communities.[6] However in 2007, it became clear that ESCOM were unable to generate enough power to cater for the entire nation simultaneously and it was at that point when stages of loadshedding were first implemented aimed at preventing the entire power grid from collapsing due to high electricity demand. Although loadshedding is an effective short-term solution to prevent to total collapse of the electricity supply grid, it disrupts the stable and continuous operation of research animal facilities, which can cause devastating consequences for Animal Welfare, research outcomes, and regulatory compliance. Implications of loadshedding on the economy have been investigated and documented for example a customer survey conducted by Akepji *et al*.[7] that led to the creation of economic models illustrating the impact of loadshedding to the South African economy. In another study, Schoeman and Saunders,[8] investigated the consequences of loadshedding on small business in Johannesburg. Ateba *et al.* (2019)[9] investigated the impact of loadshedding on industrial operations while Goldberg (2015),[10] explored the effects of loadshedding on the retail sector. Loadshedding does not only negatively affect the economy, but also puts pressure on the healthcare system. Gehringer, Rode and Schomaker (2018)[11] conducted a study to examine the effects of loadshedding on paediatric health and their findings concluded that loadshedding increased paediatric hospital admissions by 10%. Healthcare professionals are finding it very difficult to provide and maintain essential healthcare services during loadshedding, with issues ranging from the inability to sterilise equipment to the disruption of critical electronic devices and equipment.[12]

There is paucity of literature regarding the impact of load shedding on Animal Welfare, experimental outcomes and research animal facility operations but the Boon *et al.* (1983)[13] study found that brief power failures are more detrimental to pigs in extreme hot or cold conditions than in moderate weather. Documenting the effects of loadshedding on RAFs is crucial for identifying weaknesses and enabling the implementation of mitigation measures, given the apparent global problem of loadshedding currently affecting multiple countries. For example, Zambia's national power utility has implemented loadshedding which can extend for up to 12 hours daily.[14] Ghana experienced periods of loadshedding lasting 16 hours a day,[15] while Pakistan commonly experiences power cuts due to electricity shortages and distribution problems.[16] Nepal has had power shortages, where parts of the country would be without power for up to 14 hours daily.[17] In 2003 there was a very large power outage in the North eastern United States of America, which lasted for over a day (Lin *et al.*, 2011).[18] It has become evident that loadshedding remains a possibility in most resource poor countries since electricity generation infrastructure is now obsolete. The information documented in this article also applies to any other form of electricity supply disruption to research animal facilities that can emanate from any other challenges such as distant acute onset disasters (fire, earthquake, etc.).

Impact of loadshedding on animal health and welfare

Appropriate animal housing and maintenance of a constant environment is essential for animal wellbeing as well as the quality of animal research. Laboratory animals should be housed within temperature, humidity, light cycle and air changes appropriate for the species. Unlike animals in the wild (their natural environment), laboratory animals are housed in confined spaces for their entire life. The stress caused by the limited environmental space as well as variation in environmental parameters (e.g. temperature) can negatively impact the animals' physiological state and consequently confound experimental outcome. The heating, ventilation and air conditioning (HVAC) system is used to maintain a constant environment required in a RAF, and for optimal functioning and relies on a constant electricity supply. Loadshedding has made it very difficult for RAFs to maintain a constant housing environment for laboratory animals.

Exposing laboratory animals to temperature and humidity fluctuations can lead to behavioural and physiologic changes with negative implications on Animal Welfare and research outcome.[19,20,21] In the case of rats, low relative humidity, may result in a condition called ringtail. Ringtail is a condition involving ischemic necrosis of the tail and sometimes toes.[22] On the other hand, high relative humidity may lead to high ammonia concentrations in the cage environment[22,23] which can irritate the nasal passages and potentially alter some biologic responses because of the stress reaction.[24] It is also important to note that body temperature has been observed to play a crucial role on metabolism and cardiovascular function. Notably, significant differences have been observed in mice housed at temperatures between 20 to 26°C when compared to those housed at 30 to 31°C, in terms of metabolism level[23] and immunity and tumour

growth.[25] These temperature related variations can have implications for data emanating from animals used in scientific experiments leading to biased experimental results as well as interpretation of results.

Variation in the lighting cycle has been found to disturb the natural biological rhythms, leading to physiological changes such as melatonin production suppression, sympathetic nervous system stimulation and alteration in the circadian clock gene expression. Studies have shown that heart rate of rats housed in a standard 12 light and 12 dark cycles at 200 lux light intensity is higher when compared to that for rats housed at a light intensity of 10 lux. Additionally, increasing the dark cycle to 16 h (8 hours light and 16 hours darkness) at 200 lux decreased the heart rate of undisturbed male rats. Additionally, loadshedding can disrupt the normal feeding and water drinking patterns for laboratory animals, which can lead to dehydration, starvation and other health issues. The lack of ventilation and air circulation can also create a hazardous environment for animals, that can lead to respiratory and other health problems.

Impact of loadshedding on experimental data quality

In RAF, the quality and integrity of experimental data is critical for the advancement of science. However, loadshedding can have devastating consequences on the conduct of experiments and negatively impact the quality of experimental data. Experimental outcome can be influenced by loadshedding in the following ways:

- disruption in sample collection times

Researchers may face challenges in maintaining consistent sample collection schedules due to sudden power interruptions. Time-sensitive experiments, such as those involving biological samples or chemical reactions, may be compromised.

- disruptions to data recording equipment

Additionally, power outages can also cause disruptions to data recording equipment, leading to lost or corrupted data. The continuous collection of data cannot be completed between cycles of loadshedding or are disrupted when loadshedding stages are changed at short notice. This affects the generation of data and results in not only the loss of samples (and animals in the case of animal surgery experiments) but it does negatively affect projected timelines. Changes in parameters of equipment during a run can also affect the accuracy and validity of the data generated, requiring experiments to be re-started or repeated with major implications for delivery on project milestones.

- inappropriate sample storage conditions

For instance, a power outage can affect the temperature at which samples are stored, potentially confounding the results of the experiment.

- delayed sample analysis

Research animals are often used in experiments that require precise control of environmental conditions as discussed in the Welfare section. Loadshedding can disrupt the controlled environment needed for experiments, leading to inaccurate results, loss of experimental animals and waste of valuable resources. Moreover, even if the experiment is not completely lost due to a power outage, the quality of the data can still be compromised.

Impact of loadshedding on regulatory compliance

RAF are subject to strict regulatory requirements, which are designed to ensure the safety and welfare of animals and researchers. Loadshedding can compromise compliance with these requirements which can have serious consequences for both animals and researchers. These regulations often require that animals be housed under specific environmental conditions, such as temperature and humidity control and that their care is overseen by trained professionals. Additionally, regulations often require that researchers undergo training in Animal Welfare and that they follow specific protocols for conducting experiments with animals. Failure to comply with these regulations can result in legal and financial penalties, as well as damage to the facility's reputation. As such, RAFs must work diligently to ensure that they follow all relevant regulations and that they are providing the highest level of care to the animals in their care. For instance, many regulatory guidelines require that animals receive a minimum level of lighting and environmental control. Loadshedding can cause these requirements to be violated, leading to regulatory compliance issues and potential penalties.

Damage to equipment and loss of specifications

Supply interruptions and changeovers due to loadshedding impacts the electrics and functionality of research equipment and will result in damage to equipment such as incubators, freezers and related biobanking equipment used for storage of invaluable research samples and specimens, which cannot be recovered if lost. Insufficient capacity to maintain the HVAC systems capacity causes spikes in temperatures in the laboratories which impacts research activities and the functioning and lifespans of freezers in these areas.

Power supplies and battery back-ups for the access-controlled card reader doors fail without constant power and when there is insufficient time to recharge between loadshedding cycles. This has resulted in personnel being stranded in or outside of their offices and/or labs on several occasions, resulting in serious safety concerns and not being able to take care of animals. This is also a major concern as the doors are open and anyone can gain access to the laboratory and disrupt animal experiments. Without restricted access on the doors, anyone can walk into the laboratory and remove these samples.

Occupational health and safety implications

Occupational health and safety is a multidisciplinary field that is concerned with the health, safety and welfare of people working in the research animal facility. Occupational health and safety is important for personnel working in RAFs because it reduces risks or accidents or injuries by identifying and mitigating the hazards.

The RAFs occupational health and safety manual requires that safety protocols should be implemented to protect personnel from injury. With the current problem of loadshedding, several occupational health and safety protocols cannot be implemented or followed thereby putting personnel working in the lab and people outside the lab at risk.

Specifically, loadshedding can impact the ventilation, lighting, and temperature control systems that are essential for maintaining a safe working environment for personnel. For example, loadshedding can affect the microbiological monitoring of individually ventilated cage systems, which can lead to an increased risk of infectious diseases spreading between cages and the exposure to the personnel.

For example, ventilation is not providing appropriate air quality and a stable environment. Equipment that dilutes gaseous and particulate contaminants including animal dander, fur, urine smell, soiled bedding, allergens and airborne pathogens is affected. The moisture content and temperature of the room air can create air pressure differentials (directional air flow between adjoining spaces). If not autoclaved beforehand, allergens can be transferred out of the RAF on documents, or clothing.

Financial implications

In addition to the disruptions as outlined here, the lifespan of equipment would be adversely affected which would have severe financial implications.

Potential solutions to mitigate the impact of loadshedding

There are several potential solutions to mitigate the impact of loadshedding on biocontainment RAF. Loadshedding can have a significant impact, as it can disrupt the power supply needed for research activities. To mitigate the impact of loadshedding, there are several potential solutions that can be implemented. First, RAF should invest in backup power sources, such as larger generators, uninterrupted power supply (UPS), inventers and solar power systems. Generators can be used to provide a reliable source of power during loadshedding, while solar power systems can provide a more sustainable and cost-effective solution. Second, RAF should consider investing in energy-efficient equipment and appliances. This can help reduce the amount of energy needed to power the facility, which can help reduce the impact of loadshedding. Third, RAF should consider implementing energy conservation measures, such as using energy-efficient lighting and appliances, and using natural ventilation and cooling systems. These measures can help reduce the amount of energy needed to provide power and can help reduce the impact of load shedding. Finally, RAF should consider investing in energy storage solutions, such as batteries and flywheels. These solutions can help store energy during times of low demand and can be used to provide a reliable source of power during loadshedding. By implementing these solutions, RAF can reduce the impact of their operations and ensure that their research activities are not disrupted. Mitigation can be eased in larger generators that have the capacity to load all the essential equipment, installation of inverter, or an uninterrupted power supply (UPS). Invest in renewable energy system such as solar and wind.

It is important to have emergency and disaster plans in place, these plans should include procedures for moving animals to cooler areas, ensuring that animals have access to ample cool water and checking animals regularly throughout the day for signs of heat stress. Furthermore, animal facilities should be constructed to the needs of the scientific team while ensuring appropriate husbandry care of the animals. In addition to these strategies, it is important to follow health and safety regulations to ensure the wellbeing of animals and personnel. For example, the Occupational Safety and Health Administration (OSHA) provides guidelines for the safe handling of animals in a research facility, including the use of personal protective equipment, proper ventilation and the handling of hazardous materials. Training personnel on how to operate safely during loadshedding events. This training should include procedures for preventing injuries and exposure to hazardous materials.

Conclusion

In conclusion, loadshedding can have a significant impact on RAFs, affecting Animal Health and Welfare, experimental data quality and regulatory compliance. Without reliable energy access, facilities are unable to operate effectively, leaving scientists unable to develop new treatments, products and technologies. It is evident that RAF in South Africa should address the issue of loadshedding to sustain scientific research.

To avoid the devastating consequences of interrupted power supply, measures for backup power supply should be put in place such as generators or solar systems. Sufficient generator capacity should be available to maintain normal operation in the event of power outage or breakdown of mechanical systems. However, these systems are not able to provide power to all major equipment, such as large autoclaves, cage washing machines and the HVAC system. Thus, it is imperative to remain prepared for unexpected power outages. It is also important that RAF work with energy providers and heads of institutions to explore ways to minimise the risks associated with loadshedding. By taking these steps, RAFs can continue to make important contributions to scientific knowledge and the development of new treatments. We recommend that further studies be conducted to analyse the effect of loadshedding on Laboratory Animal Welfare by evaluating stress hormone responses during different stages of loadshedding.

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