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Abstract: 5465

Safety/QA/QI Projects

Environmental Impact of Medical Ultrasound Use

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Introduction

One of the most notable innovations in modern healthcare has been the broad adoption of ultrasonography. However, in the era of climate change, it is important to be cognizant of potential environmental waste. Scope 2 emissions, defined as carbon emissions due to purchased electricity, are needlessly magnified by a lack of education on best practices when using electronic and battery devices such as ultrasounds. Similarly, scope 3 emissions, the carbon emissions produced by buying, using, and disposing of products, are a main concern with disposable batteries in portable ultrasounds. We aim to investigate scope 2 and 3 emissions related to ultrasound electrical waste at our institution and identify opportunities to reduce hidden environmental impacts.

Materials and Methods

At NewYork-Presbyterian Weill Cornell Medical Center, the Department of Anesthesiology uses multiple ultrasound machines for diagnostic and therapeutic purposes, including three models of the same brand. Using available information on the manufacturer's website, we investigated the electrical output, battery characteristics, and screen power settings of each device. From that information along with carbon emissions data [1], we calculated the theoretical electricity use and associated carbon emissions for different ultrasound use scenarios. This data is presented as a quality improvement project, therefore no IRB/IND approval is required.

Results/Case Report

According to the manufacturer's website, each machine has a 10.8 V and 5200-5800 mAh lithium-ion battery, although current output is limited to five amperes on each machine. When in use, each machine can draw up to 75 watts. Of note, when connected to an AC wall source, they preferentially use AC power and simultaneously charge their batteries. Unattended, they will automatically revert into sleep mode (i.e. decreased power draw) after 5-10 minutes and power off completely after 15-30 minutes. Battery lifespan is between 300-700 cycles depending on the pattern of use and lithium-ion salt.

In our daily practice, the active use of ultrasound machines tends to be brief, however, machines are commonly running on battery or AC power before and after use. Sleep mode and power off settings are defaulted to the maximum 10-minute and 30-minute intervals, respectively, contributing further to electricity wastage. Assuming an average two-hour downtime per ultrasound per day (approximately 20 minutes per hour over a six-hour block day), over 54 kWh would be lost to non-productive ultrasound time per year. Given that an average of 0.39 kg CO_2 is emitted per kWh of electricity in the United States, the aforementioned wastage would contribute >21 kg CO_2 emissions per machine.[1] There would also be a small financial impact - approximately $14.81 - given local electricity costs.[2] It should be noted that this does not account for the decrease in battery life, leading to premature battery disposal and replacement, which falls under Scope 3 rather than Scope 2 emissions.

Modern lithium-ion battery degradation is, speaking broadly, due to loss of chemical integrity over time. Major factors include battery composition, cycle counts, state of charge, and temperature.[3] Cycle counts are the accumulated instances of charging and discharging associated with battery use. Wasted battery charge consumes some proportion of lifetime cycles, leading to earlier disposal and replacement. State of charge, the percentage of total battery charge at a given time, contributes to decreased battery life most at states of near-maximal and near-minimal charge. Similarly, temperature's battery life impact is most significant at the extremes: below 0°C and above 60°C.[4] However, small losses in efficiency will occur with deviation from a 25°C ideal battery temperature. Also, battery temperatures may fluctuate broadly with variable states of charge and frequent use. These variables contribute toward the common endpoint of battery degradation and eventual failure. Using the prior assumption of two hours of standby time per day, one could expect almost an entire battery cycle lost per day. Over a year, several hundred wasted battery cycles might accrue: a significant amount toward the expected 300-700 lifetime cycles. This is accelerated if the battery drains to a low state of charge. Therefore, the battery might need replacement much earlier than expected, costing several hundred dollars and creating additional hazardous landfill waste.

Discussion

The largest contributor to unnecessary scope 2 emissions is failing to turn off the machine between uses, requiring additional "plug-in" time to replenish lost charge. This leads to wasted electricity in real-time, and the inability of the battery to hold a charge long term, further increasing required "plug-in" time. This process subsequently increases scope 3 emissions from the need to dispose of and replace spent batteries sooner than ideally needed.

The need to replace equipment and batteries sooner than expected likely contributes more emissions overall than the scope 2 emissions calculated in our investigation. These emissions are more difficult to quantify since recycling rates are not well-reported, and manufacturer documentation does not specifically outline the type of lithium-ion battery used. Regardless, end-of-life batteries are much more likely to be disposed of rather than repurposed, contributing to toxic material potentially leaching into groundwater.[5] Manufacturers are obliged to safely dispose of their batteries at no cost to the consumer. In practice, penalization for improper disposal is rare. Even when recycled, the decrease in greenhouse gas emission depends on the particular lithium-ion salt (e.g. cobalt vs manganese oxide) present.

Electricity waste, as outlined above, will depend on the length of time an ultrasound is drawing power but not being used. A simple initial approach to decrease waste is to adjust the set times to automatic sleep and power off modes to the minimum allowed in the ultrasound battery settings. This would limit power consumption for each machine regardless of the pattern of use. Educating clinicians and staff to only turn on machines immediately before needed and immediately turning them off afterward, would circumvent even the brief delay to "sleep mode" or powering off, but would rely on the individual practitioner. By preventing electricity waste in these ways, scope 3 emissions could also be saved by reducing battery cycles and prolonging battery life. While our calculated emissions and cost savings are low, the greater environmental impact will be extending battery life to prevent premature replacement and disposal of lithium-ion batteries.

References

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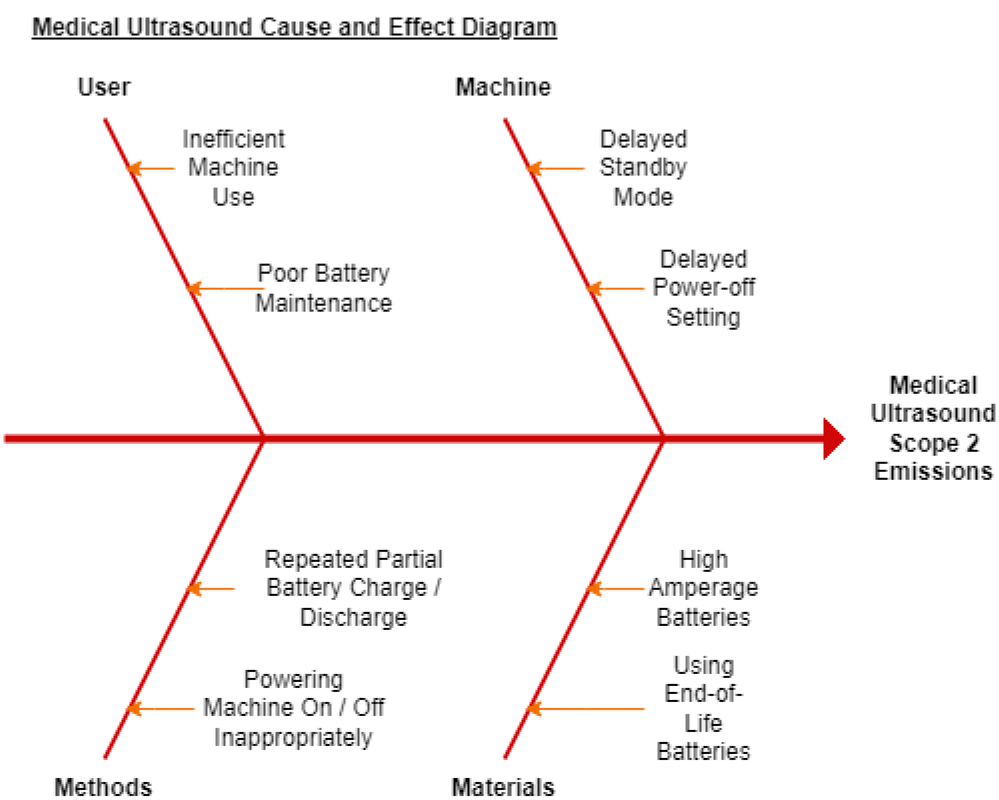
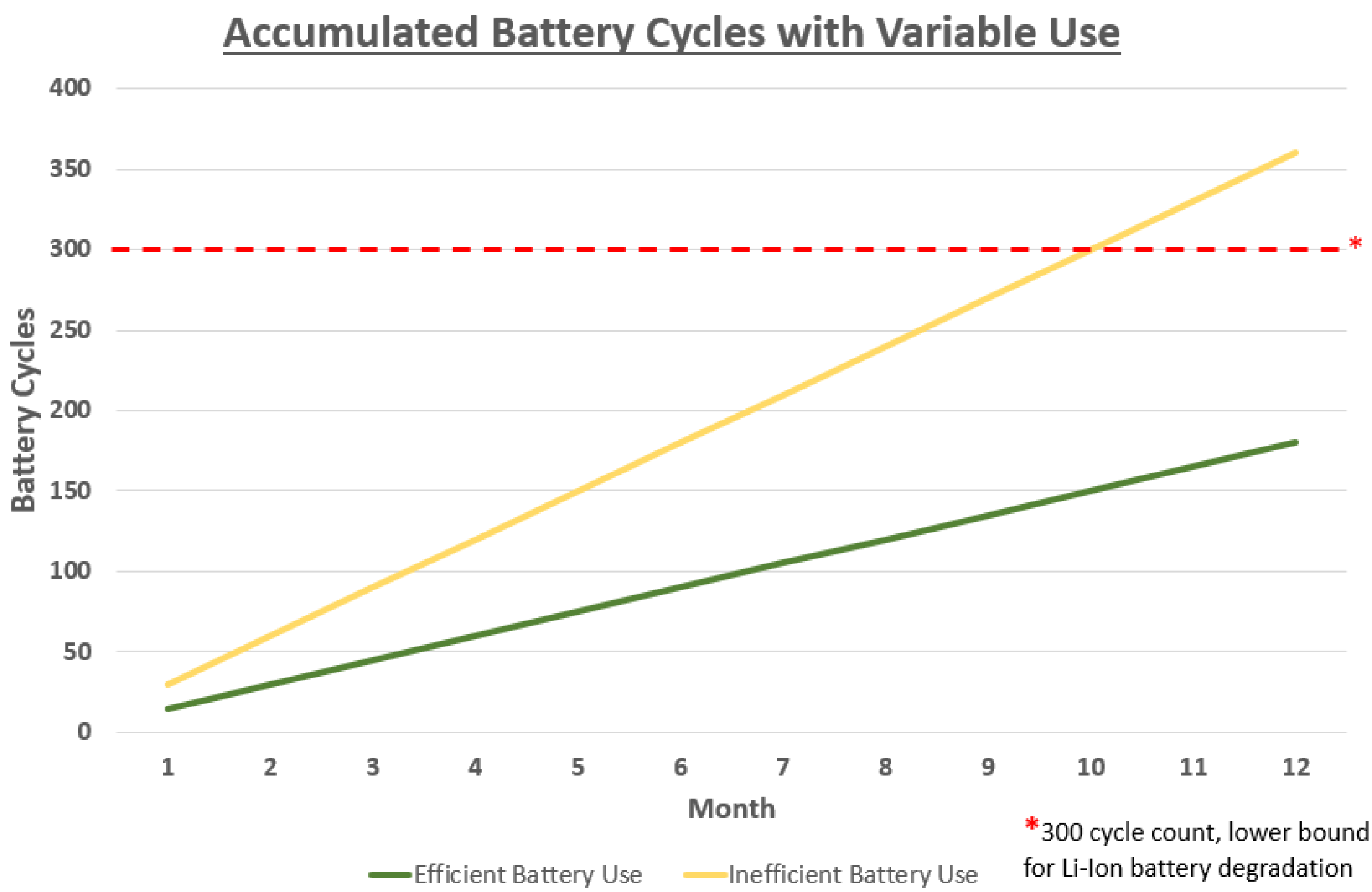
Disclosures

No

Tables / Images




Accumulated Battery Cycles with Variable Use
400
350
300
250
200
150
100
50
0
Battery Cycles
1
2
3
4
5
6
7
8
9
10
11
12
Month
*
Efficient Battery Use
Inefficient Battery Use
*300 cycle count, lower bound for Li-Ion battery degradation