

Silent Nursery: Button Battery Fatalities in Children—the Long Road from Externality to Obsolescence

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Abstract

Button batteries are a lucrative product for manufacturers, but for toddlers they are a death pill. The designs for button batteries are now decades old, the research investment and tooling for production have long ago been amortised. Child deaths are an economic externality for manufacturers, i.e., a child death or injury attracts no cost imposition for manufacturers. Child button battery fatalities are a classic market failure, of a technology where the profits are privatised and the harms are socialised. The design problem of these batteries is that they are liable to be swallowed by toddlers, to lodge in their oesophagus, to burn through tissue, and to thereby cause death (unless they are promptly removed within hours of ingestion). The issues have been known for decades, yet the design issues have not been resolved, and toddlers continue to be collateral damage and unaccounted economic externalities. In the US there have been 44 child deaths from lithium button batteries in the past two decades (2002-2021). Known child deaths in USA average 2.2 per year (with a low of 0, to a high of 6). Of these lithium button battery deaths, where the diameter was recorded (n=43), all were 20 mm diameter batteries. The thickness of the fatal batteries varied: 1.6 mm (n=1); 2.5 mm (n=6); 3.2 mm (n=18); with the rest of unknown thickness (n=19). Death by button battery is not notifiable so these figures will be underestimates of the harm. The issues are (1) 20 mm lithium button batteries are ubiquitous (most car remotes use such batteries, e.g. CR2032); (2) these batteries are readily available to consumers, and remote key fobs (and other consumer items) are designed for the consumer to replace spent batteries; (3) there is low awareness that button batteries are dangerous goods that will kill if ingested, and as a consequence loose and/or spent batteries may be left unsecured and unattended; (4) button batteries are shiny and attractive to toddlers and pre-schoolers who are known to be indiscriminate in what they ingest; (5) an ingested button battery of 20 mm can lodge in the oesophagus of a young child (smaller batteries can more readily pass through a young alimentary canal); (6) the design of lithium button batteries can result in an ingested battery corroding a fistula (a tunnel) in the oesophagus wall through to the trachea or aorta, either of which is fatal; (7) the symptoms of button battery ingestion lack specificity and may be misdiagnosed as benign (with fatal consequences). While manufacturers and regulators continue to treat button battery deaths as externalities and as collateral damage the deaths can be expected to continue. Twelve recommendations to save child lives from death by button battery are presented.

Keywords

Button cell batteries, coin cell batteries, lithium batteries, product safety, product standards, unsafe products, product liability, public health, child safety, paediatric patient safety, car key fobs, fistula, USA, recommendations

1. Introduction

Button batteries are a known risk of death to young children [1-4]. Young children are attracted to shiny objects and have a propensity to indiscriminately put things in their mouth, predominantly coins and batteries [5]. Non-food foreign objects are generally not life threatening because they are neither poisonous nor bio-reactive. Button batteries are the exception, they are highly bio-reactive, even spent batteries [6].

Button batteries, also described as coin cells, are coin-shaped - round and flat. The two faces of the battery are terminals, electrodes, and this design feature makes them uniquely lethal for children. A child is at greatest risk with lithium button batteries of 20 mm diameter, the typical battery used, for example, in car key fob remotes. The diameter of these batteries means they can lodge in the oesophagus of a child if ingested (rather than passing through the alimentary canal and being excreted in faeces).

Button batteries of a certain size (20+ mm) are a problem known for decades without resolution by the multi billion dollar industry. For manufacturers, child deaths are an economic externality, collateral damage, and do not appear in the accounts. The harms are borne wholly by the community.

The button battery industry has been valued at US\$3.9 billion [7]. This is a lucrative industry. In bulk quantities, CR2032 batteries are available wholesale for US\$0.01 each [8, 9]. Retail they are offered at AU\$4.95 each [10]. The research design and tooling has long ago been amortised. The industry continues to offer products into the consumer market that have been known “for several decades” to be unsafe and fatal for a toddler who ingests one [11].

Button batteries have been described as “unsafe by design” [4, p. 302], as “a unique corrosive hazard” [3, p. 1254], and they, “unlike all other foreign bodies, can cause catastrophic injuries ... within hours of ingestion” [6, p. 1]. The design maximises the surface area of the terminals (the electrodes) and thereby maximises the opportunity for bio-reaction and tissue damage if ingested. Most fatal ingestions are unwitnessed (92%) and many (54%) are initially misdiagnosed [1].

An Inquest into a button battery death stated: “When a lithium battery is ingested, saliva triggers the battery to generate an electrical current, resulting in electrical burns caused by the electrolysis of tissue fluids and hydroxide produced” [12, p. 6]. If lodged in the child’s oesophagus, the consequent corrosion of the wall of the oesophagus can create a fistula (a tunnel) through to the child’s aorta or trachea (depending on the location and orientation of the lodged battery). Such a fistula will quickly prove fatal.

In an effort to address the issue of child button battery deaths, new legislation in Australia requires, from 22 June 2022, compliance with the following four “mandatory safety and information standards”:

- 1) Consumer goods containing button/coin batteries that are intended to be replaced by the consumer must have a secure battery compartment that is resistant to being opened by young children.
- 2) Consumer goods containing button/coin batteries, whether or not the batteries are intended to be replaced, must be secure and not release the batteries during reasonably foreseeable use or misuse conditions.
- 3) Compliance testing must demonstrate that safety requirements have been met.
- 4) Warnings are required on the packaging of consumer goods containing button/coin batteries and in accompanying instructions. If the consumer good is supplied unpackaged, or not supplied with instructions, warnings must be attached or included with the consumer good to alert consumers that a button/coin battery is included with the product and the hazard button/coin batteries pose to children [13, p. 2] (Fig. 1).

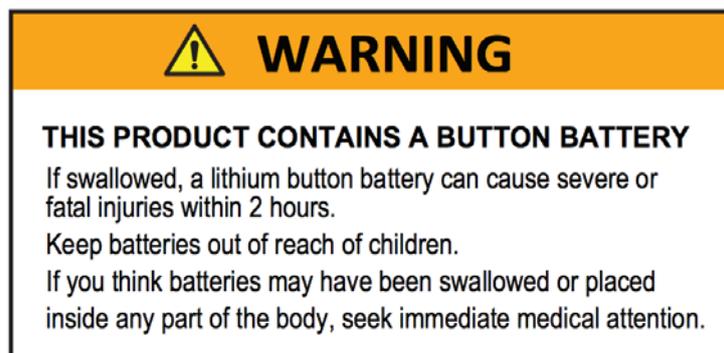


Figure 1. Example of packaging warning for a product containing a lithium button battery [13, p. 2].

2. Materials and Methods

Fatal button battery deaths have been compiled by the National Capital Poison Centre (NCPC) in Washington and it is this data set that is analysed in the present paper [14]. The NCPC data set is collated from media reports from 1977 to 2022 and appears to be the most comprehensive data set available. No further fatalities were identified in the media by the present author. This method of compilation (viz. from media reports) will result in an under-reporting of fatalities. Some button battery fatalities, and perhaps most such fatalities, will not appear in the media, given that every such death of a child will leave in its wake a family in mourning, and some will seek privacy in their grief and some will seek publicity in their anger.

There are various technologies for button batteries, the most common being lithium. In the data set (n=69), where the battery technology is unknown (n=23) the cases are excluded from the present analysis. The outlier historical fatalities reported for the 1970s (n=2) are also excluded from the analysis; there appears to be a discontinuity in the data set data with no cases reported for the decade 1980 through 1990. After the noted exclusions, the cases analysed (n=44) are fatalities from 2002 through 2021 where the battery technology is reported. The age of the children was categorised by year, in steps of one year (viz. 1 year+ = 12 -23 months etc).

There is international standard nomenclature. Button batteries are coded with the battery technology, the diameter, and the height. Button batteries are coded with 6 alpha-numeric characters. For example, a common button battery is 'CR2032'. The first two characters indicate the technology: C = electrochemical system, lithium; R = round. The numerals indicate the size: 20 = 20 mm diameter; 32 = 3.2 mm high [15].

3. Results

Button battery ingestion is liable to be misdiagnosed by doctors. This is due to the presenting symptoms being similar to variations of common childhood benign maladies [1]. From ingestion to death may take several weeks during which the child will be unwell and exhibit a variety of symptoms [14].

Forty four US children have died a painful death in the period 2002 to 2021 from the ingestion of button batteries of known technology. Deaths averaged 2.2 per year, with an annual low of 0 and a annual high of 6 (Fig. 2).

All the fatalities were children under 6 years old. Of these, 41% were boys (n=18), 57% were girls (n=25), and 2% were of unknown gender (n=1). One year olds (12-23 months) accounted for the majority of cases, 52% (n=23). Children under 12 months accounted for 7% of cases (n=3); of these, the youngest was 2 months old with the fatal button battery "fed to child by elder brother" [14, p. 13]. The youngest self-administered case was a 3 months old. Children 2 years old accounted for 20% of fatalities (n=9). Children 3, 4, or 5 years old accounted for a further 20% (nn=3,5 &1) (Fig. 3).

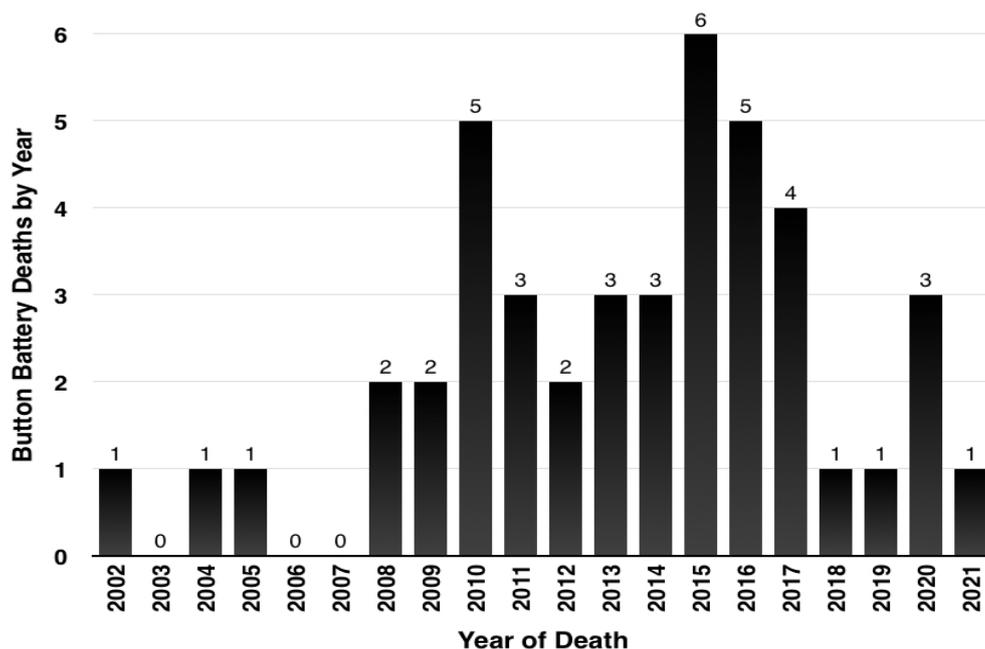


Figure 2. Button battery deaths ($\Sigma=44$) per year (data source: NCPC, 2022).

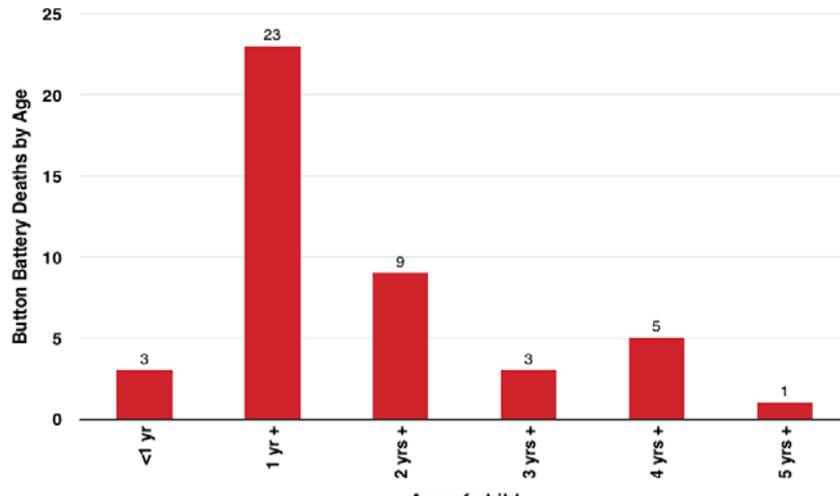


Figure 3. Button battery deaths ($\Sigma=44$) by age of child, age 1 year (12-23 months) accounts for 52% of cases (data source: NCPC, 2022).

These children died painful and distressing deaths. Some batteries were discovered before death and some were removed, others were not removed prior to death. The typical pattern is that the button battery lodged in the oesophagus, at which point it burned through the tissue wall. Depending on the orientation of the battery at the time of lodgement the battery proceeded to burn through to the trachea (wind pipe) (tracheoesophageal fistula). In other cases the embedded battery burned through the oesophagus wall through to the aorta (aortoesophageal fistula). These were typical outcomes following lodgement. Other cases reported the fistula extending from the oesophagus to the pulmonic artery and another to the carotid artery.

The location of lodgement was the oesophagus in 87% of cases (n= 39), the stomach in 9% of cases (n=4), and the intestine in 4% of cases (n=2). The figures account for 45 lodgements in 44 children; in one case a child ingested 2 batteries, with one lodging in the esophagus and the other lodging in the stomach. In the non-oesophagus lodgements, it was typical that the initial lodgement was in the oesophagus before travelling onward [14].

Of the 44 fatalities, 98% were due to 20 mm diameter lithium button batteries (n=43), in one case the lithium button battery diameter was undetermined. CR2032 batteries (round lithium button batteries, 20 mm diameter, 3.2 mm high) accounted for 41% of fatalities (n=18). CR2025 accounted for 14% of fatalities (n=6). CR 2016 accounted for 2% of fatalities (n=1). CR20 batteries of undetermined height accounted for 41% of deaths (n=18). In a single case neither the battery diameter nor height were recorded (Fig. 4).

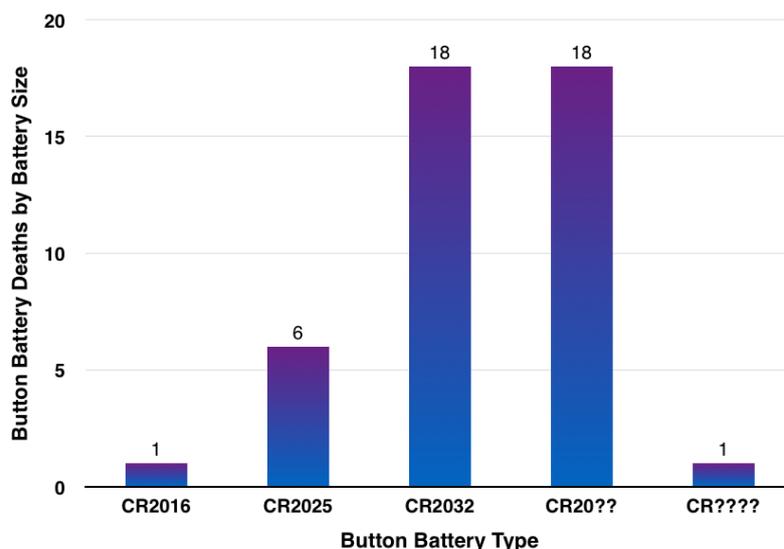


Figure 4. Button battery deaths ($\Sigma=44$) by size of battery, 98% are due to 20 mm diameter batteries (n=43), the most common battery height is 3.2 mm (n=18) (data source: NCPC, 2022).

4. Recommendations

Children have no voice in the safe design of their living spaces. The safety of children relies on adults. In the case of button batteries, children have been failed in this regard. It is past time to remedy the situation. The following recommendations are presented with the view to making life safer for children until the lethal button batteries are made obsolete by either regulation or design.

4.1 Redesign lethal button batteries

Comment: Certain button batteries are lethal (viz. 20 mm lithium button batteries). It is not the task of the present author to design the death out of these lethal batteries. Nevertheless, here are two suggestions: (1) if the batteries are redesigned as (for example) 12 mm diameter batteries, the problem is solved. Hearing aid batteries are typically 12 mm lithium batteries, they are not liable to lodge in the oesophagus of a child, and they are excluded from the Australian button battery legislation [13]; (2) the batteries are redesigned with plastic faces and gasket and the terminals (electrodes) are recessed inside the plastic casing; this will make the presently bright shiny batteries less attractive to infants, it will not stop such a battery lodging in the oesophagus, if ingested, as a foreign object, but it will stop the electrolytic burning of the surrounding flesh, and will thereby avoid a fatal fistula.

Recommendation 4.1: *Lethal button batteries are redesigned as safe products - safe-by-design.*

4.2 Ban lethal button batteries

Comment: Button batteries vary in size, usually 5 to 25 mm in diameter and 1 to 6 mm in height and there are various technologies [16]. The batteries that are fatal to children when ingested are generally lithium batteries of diameter 20 mm (or larger) (Fig.4). Such batteries, e.g. CR2032 are found in car key fobs of major car manufacturers, including: Toyota; VW; Mercedes; Ford; Honda; Renault, et al. Hearing aid button batteries are typically 12 mm in diameter (or less) and of a size that is not liable to lodgement in the oesophagus, and are hence likely to be excreted via the faeces; the damage they may do on such passage through the child's alimentary canal is not fatal. A button battery ban can be selective to the lethal button batteries.

Recommendation 4.2: *Button batteries known to cause child deaths are banned by the regulator (viz. Lithium button batteries of 20+ mm diameter).*

4.3 Planned obsolescence

Comment: The concept of planned obsolescence is long familiar to industry [17, 18]. Planned obsolescence has always been to aid profit. Nevertheless the same concept can be harnessed for making safer the world of children. Lethal button batteries can be made obsolete by industry where there is the will. To engage such a will may require regulatory and/or punitive incentives.

Recommendation 4.3: *A timeline to obsolescence is instated with a sunset date at which point lethal button batteries (viz. Lithium 20+ mm button batteries) are out of the market.*

4.4 Public liability

Comment: Corporations do not feel the pain of grief but they do understand money. Companies can be incentivised to make their products either obsolete or safe. This can be achieved by a nominated harm (e.g. a button battery child death) triggering a monetary payout. The payout could be a fixed amount which can be set by government to be commensurate with the button battery industry being a multi-billion dollar industry, and the problem being a known problem for two decades.

In the pursuit of liability the regulator needs to consider the supply chain of manufacturing which will comprise various entities. There is the original equipment manufacturer (OEM) which supplies the branded item (for example a car with key fob) to the customer. There is the Tier 1 manufacturer of the key fob (for example), supplying to the OEM. There is the Tier 2 manufacturer of the button battery, supplying to the Tier 1 manufacturer. The supply chain may be deeper than two tiers, or shallower.

Recommendation 4.4: *A child death by button battery attracts a no-fault substantial payout by the button battery manufacturer, the OEM manufacturer, and any intermediate Tier suppliers, to the family for the harm of the death (viz. compensatory and punitive or exemplary damages).*

4.5 Criminal responsibility

Comment: Consider, a loaded gun is left where it is accessible to an infant who then unintentionally kills himself.

Such a death is beyond an ‘accident’ and beyond a ‘misadventure’. There is an element of criminal negligence. If ingested, button batteries are equally as lethal as a loaded gun; a difference is that the button battery death will be more drawn out, be more painful over an extended period of (typically) weeks, and cause more suffering to the victim.

Recommendation 4.5: *Child deaths by button battery should be investigated with a view to criminal prosecution of the party who left the button battery accessible to the child.*

4.6 Reportage and statistics

Comment: Present data on button battery deaths is incomplete. The report of the NCPC relies on press reportage. This guarantees that some cases will be missed. Present reportage relies on (1) the personal and private distress of parents finding voice in the public domain, coupled with (2) the enterprise of local media to report these child fatalities as ‘news’.

Recommendation 4.6: *Child button battery deaths are a notifiable cause-of-death to an appropriate government health authority.*

4.7 Withdrawal of social license

Comment: Products with lethal button batteries are non-essentials (being neither food nor shelter), some are luxury items. Manufacturers rely on a ‘social license’ to market their products as good, safe, and virtuous. They do not want to be painted as villains, yet selling goods that kill children may be seen as villainous behaviour by the public. Social media could be the perfect medium for the spreading of such characterisations and linking these death pills to targeted manufacturers who treasure their reputation.

Recommendation 4.7: *Manufacturers take the initiative and pre-emptively withdraw lethal button batteries and specify lethal button batteries out of their supply chain, to head off a prospective campaign of ‘name and shame’, instituted with the view to shaming manufacturers and retailers into such a withdrawal.*

4.8 Lipstick-on-a-pig ‘innovations’

Comment: ‘Lipstick-on-a-pig’ ‘innovations’ such as adding a bittering agent to button battery terminals [19], are a distraction. They are arguably contrived to ‘pull the wool over the eyes’ of regulators. They should be called out and rejected. The problem is the lethality of ingested batteries, the batteries are the problem. The taste of the batteries is neither the problem nor the solution. Young children, pre-schoolers, have a propensity to grab, mouth and swallow foreign objects, some pre-schoolers more so than others. These toddlers are not connoisseurs. They are not mimicking the behaviour of wine (or chocolate) aficionados, who by accounts savour the taste, aroma, and ‘mouth feel’ of a fine wine (or chocolate). Pre-schoolers are not in the savouring business. By the time a one year old child realises the bitter taste, if they can indeed register ‘bitter’, the battery will be swallowed.

Recommendation 4.8: *Button Battery ‘innovations’ that appear to be designed to deflect regulatory oversight should be disregarded by regulators.*

4.9 Community awareness

Comment: There appears to be low community awareness of the danger of button batteries to young children.

Recommendation 4.9: *Until 20mm lithium button batteries are obsolete, a program of community awareness-raising is implemented.*

4.10 Warning labelling

Comment: Lethal button batteries are sold in supermarkets without warning labelling. In Australia, a warning label (Fig.1) is mandated from 22 June 2022, but is yet to be sighted in practice.

Recommendation 4.10: *Tobacco-style warning labelling on packaging to be mandated and overseen by an appropriate government agency.*

4.11 Restricted sales outlets

Comment: Lithium button batteries are an unsafe product. It is appropriate that the sale of an unsafe product is a controlled sale. A precedent is that in Australia it is mandated that cigarettes are sold from lockable cabinets, from behind the counter, and that they are not on display.

Recommendation 4.11: *Restrict sales outlets and/or sell from behind the counter.*

4.12 Non-serviceable batteries

Comment: A standard that specifies items containing lethal button batteries (viz. 20+ mm lithium button batteries) are non-serviceable to the customer, would get loose and unsecured batteries out of households. This can be achieved by the battery compartment being secured by specialist screws (e.g. screws with a special head that require a specialist bit to remove). An item, e.g. a key fob that needs a new battery can be taken to a service provider where a technician can change the battery employing a specialist tool. Such service providers could include existing service providers, for example key-cutters, shoe repairers, and/or mobile phone repairers in shopping centres, who already typically offer a service to change watch batteries and key fob batteries.

Recommendation 4.12: *A Standard is introduced which specifies that items with lethal button batteries are to be non-customer serviceable. A customer service provider can change such batteries using a specialist tool to access the battery compartment.*

5. Concluding remarks

The maxim applies: 'If we keep doing what we've been doing, we'll keep getting what we've been getting'. That is, more infant deaths. The problem is a decades old problem which appears to be beyond the wit of button battery manufacturers to resolve. That is not because they lack the skill to design out the death, it is rather because they lack the incentive to design out the death.

An arguable view is that Australia's ACCC approach of ring fencing the unsafe product and adding signage [13] addresses the problem of lethal button batteries from the wrong direction. An unsafe section of footpath can be ring fenced and warning signage added, or alternatively it can be made safe (Fig. 5).



Figure 5. Problems of safety can be fixed, or ring fenced with added warning signage (Image: J Paull).

The ACCC takes a live-with-unsafe-products approach when what is required is a make-the-unsafe-product-safe approach. The ACCC regulations taking effect June 2022, while a commendable effort, do not go far enough, and fail to address the fundamental issue of an unsafe product. Yes, button batteries should be securely packaged (child proof packaging) and, yes, battery compartments should be secure, and yes, by all means create awareness with warning labelling, but these efforts are not a substitute for a ban, a phase out, or planned obsolescence.

Recommendations include incentivising button battery manufacturers to design-out the death, for example by applying the instruments of product liability law and/or criminal prosecution. Terminating the accounting indulgence of treating child button battery deaths as an accounting externality will accelerate the path to obsolescence.

That lithium button batteries of diameter 20+ mm are fatal for toddlers has been known for decades. That the industry has persisted with this product in an increasing variety of consumer goods, and particularly car remotes, is a market failure and an indictment of the industry. The problem is now long overdue to be fixed. The appropriate fix is obsolescence of these dangerous and unsafe products.

Twelve recommendations are made in the present paper ranging from the withdrawal of social license through to criminal prosecution. What is clear in that the present laissez faire approach by all tiers of production, from battery

manufacturers, through to consumer product manufacturers (OEMs), as well as regulators, is that intervention by way of the 'heavy hand' of the law and regulation is called for, with the view to the obsolescence of killer button batteries. And, if not regulation, then pre-emptive action by manufacturers, or proactive action by social media. Enough is enough.

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