

Ethical Critique of The Principle of ALARP As A Health, Safety and Environment Decision-Making Tool

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Abstract: The principle of "As Low as Reasonably Practicable" (ALARP) has long served as a foundational tool in health, safety, and environmental (HSE) decision-making, particularly in high-risk industries. Grounded in cost-benefit logic, ALARP seeks to minimize risks unless further reduction would require disproportionate effort relative to benefit. This critical review analyzed the ethical strengths and weaknesses of ALARP through the lenses of utilitarianism, deontological duty, process integrity, and distributive justice. Drawing on recent literature and professional experience, the study identified that while ALARP promotes optimization, accountability, and continuous improvement, it also suffers from ethical limitations such as subjectivity, commodification of life and environment, lack of transparency, and potential injustice towards marginalized or vulnerable populations. The researchers argued that ALARP's heavy reliance on cost-benefit analysis risks monetizing human life and environment and sidelining stakeholders consent especially in contexts where residual risks affect vulnerable groups or where the groups with potential exposure to the risk are not part of the decision makers. Recommendations include embedding ethical scrutiny, procedural fairness, and stakeholder participation into ALARP-based decisions, especially where AI or algorithmic systems are involved, to ensure morally sound and equitable HSE practices in an increasingly automated world.

Keywords: Cost-benefit analysis, As Low as Reasonably Practicable, Ethical, artificial intelligence, acceptability, tolerability, deontological

I. Introduction

Safety is considered a top priority in many of today's organizations [1]. Addressing the safety concerns in projects requires assessment of risk. Therefore, the European legislative framework acknowledged the key role that risk analysis must play in the economic evaluation of projects [2]. The *Guide to the Cost-Benefit Analysis of the European Commission (EC)* for the 2014–2020 programming period identified four essential phases to assess investment risk: sensitivity analysis, qualitative risk analysis, probabilistic risk analysis, and possible definition of prevention and/or mitigation actions [2]. EC Regulation 1303/2013 clarified that risk analysis is needed in situations where the exposure to residual risk, i.e., the risk that remains despite the mitigation strategies undertaken, is substantial [2]. However, risk analysis can also be required due to the dimension of the project or in relation to the accessibility of the data required for the evaluation [2]. [3] specifically emphasized the need for comprehensive assessment of risk to identify and manage workplace hazards. One of the considerations during risk assessment is balancing the complexity of risk mitigation measures with the expected benefit.

Cost-benefit analysis (CBA) is one of the tools that can be used for such balance to enhance decision making. According to [4], CBA plays a very important role in legislative and regulatory policy debates on health, safety and environment (HSE) improvement. Specifically, CBA can help in illustrating the trade-offs that are inherent in public policy-making as well as make those trade-offs that are more transparent. Agencies can utilize the concept in defining regulatory priorities while decision-makers utilize the concept in reaching key decisions [4]. However, contrary to the views of some researchers, [4] observed that though CBA can be quite helpful in decision-making, it is neither necessary nor sufficient for designing sensible public policy. As a subset of the concept of CBA, the As Low As Reasonably Practicable (ALARP) principle, over the years, has evolved as a key concept in HSE regulation. With a background in United Kingdom (UK) law, ALARP principle has been widely adopted internationally across various industries such as nuclear, chemical, medical, and construction sectors [5]-[6]. The aim of the ALARP concept is to reduce safety risks to the levels that further reduction would demand effort, time, or cost that is considered "grossly disproportionate" to the benefit achieved, according to the definition in *Edwards v. National Coal Board* (1949) and codified in regulations like the Health and Safety at Work Act, 1974 and Ionising Radiations Regulations, 2017 [5]-[7].

In a world with increasing surge in complex systems such as automation, artificial intelligence (AI), and interconnected devices, automation of tasks to enhance efficiency is common [8] - [9]. However, with some important decisions with potential impacts on human lives, livelihoods, and the environment being automated, there exists a huge possibility for humanity to face the ethical consequences of HSE decisions that rely on ALARP principle [9]-[11]. Many researchers and scholars have, therefore, questioned

the adequacy of ALARP principle in addressing the ethical nuances associated with the subjectivity, stakeholders involvement, justice, transparency, and accountability in decisions with potential impacts on HSE [8]-[11].

This study reviewed the ethical implications of the concept of ALARP through a comprehensive lens: technical normativity, justice, process integrity, and duty of care.

Aim of study

Considering the potential pitfalls inherent in reliance on ALARP for key decision making in areas with potential impacts on HSE, the aim of this critical review was to:

1. Clarify ALARP's moral assumptions and practical scope.
2. Analyze ethical strengths of ALARP principle
3. Critique weaknesses of ALARP principle like vagueness, commodification, inequity, and moral opacity.
4. Propose enhancements to embed ethics in safety decision-making.
5. Provide insights to modernize ALARP within the evolving landscape of occupational health, safety and environment for public protection.

II. Methodology

This study adopted critical review of different studies on CBA, ALARP, and ethical concerns. The literature reviewed were retrieved through search of different reputable research databases such as Scopus, institutional repositories, Web of Science, Google Scholar, and general searches of different internet sites. Boolean operators such AND & OR were used to mesh key terms and their synonyms to find appropriate literature for the critical review. The following are the key terms and their respective synonyms used for the literature search: “As Low As Reasonably Practicable,” “ALARP,” OR “ALARP principle” AND “Cost-Benefit-Analysis” AND “Health, Safety, and Environmental decision-making.” The authors’ experience in HSE, ethics, and/or humanities guided in the selection of relevant literature and government publications. The design provided a holistic means to review the strengths, weaknesses and concerns with ALARP to enable exploration of options to enhance HSE decisions without compromising ethical principles.

The Concept of Cost-Benefit Analysis

The concept of cost-benefit analysis (CBA) provides a structured approach to enable analysis of economic benefits and costs of different policies and/or options in the development of regulations, execution of projects, or review of existing organizational practices [4]. CBA is a key tool normally adopted in evaluating HSE interventions to enable decision-makers weigh financial investment against anticipated HSE gains [12].

While evaluating direct costs can be straightforward, determining the cost of intangibles such as productivity improvements, reputation, and legal or fiscal impacts, can be methodologically challenging [13]-[15]. However, to effectively utilize CBA as a decision-making tool, it is key to accurately incorporate the intangible dimensions to reflect the full value of HSE measures. Some randomized controlled trials have reinforced this complexity and the sensitivity of CBA to study design, sample size, and variability in study outcomes [16].

CBA has been used as an instrument for decision making in occupational health and safety (OHS) investments in middle-income economies [17]. For instance, according to [17], a 2011-2015 Colombian study showed that insurer investments prevented about 4,919 injuries, about US \$3.95 million costs - evidence of solid return from the insurer’s perspective. Such perspective make CBA attractive to many who view gain through financial lens.

While traditional CBA relies mostly on economic metrics, [18] and [19] observed that frameworks like triple bottom line CBA are gaining traction as they integrate social and environmental dimensions into project evaluations, including HSE settings. Such nontraditional CBA framework helps in incorporating externalities such as environmental benefits that conventional CBA frameworks do not normally incorporate.

Irrespective of its use, the use of CBA in HSE comes with key limitations. For example, [20] noted that cost estimates can be biased or inaccurate, while the monetization of human life, productivity, or health triggers ethical contentious.

The implication is that though CBA is considered essential for HSE decision-making, the effectiveness of the CBA framework relies on addressing ethical concerns and methodological rigour such as adequately capturing intangible benefits, standardizing intangible cost valuation, choosing proper models for uncertainty, considering diverse stakeholder perspectives, and adopting broader frameworks such as triple bottom line analysis.

The Concept of as Low as Reasonably Practicable

The As Low As Reasonably Practicable (ALARP) logic was introduced in the CBA procedural scheme to provide objective criteria to establish whether the probability of investment failure is unacceptable, as low as reasonably practicable, or widely acceptable for economic purposes. The ALARP logic is a guide used to accept the risk of loss of life in high-risk sectors (energy, nuclear, oil and gas) [2]. According to [21], “The so-called ALARP principle is being introduced by regulatory authorities as a guide to achieving a satisfactory outcome for the management of industrial and other risks.” With the concept of ALARP, a risk is tolerable only if it is impossible to reduce it further or if the costs to mitigate it are disproportionate to the benefits obtainable [21]. Based on this approach, a risk is ALARP if it is between the thresholds of acceptability and tolerability (see figure 1), or if the costs of reducing it are not disproportionately high in relation to the benefits obtainable [22]. Figure 1 below depicts the principle of ALARP as shared by [2]. While the ALARP principle is typically used as a risk management strategy to make decisions upon acceptability and tolerability of risks [23], the principle represents a general way of thinking whenever the overall goal is a triangular balancing of costs, benefits, and risks [2].

To enhance such balancing, tools, such as CBA are used to weigh the balance of the amount of capital to be invested on safety on the one hand, and the extracted benefit attained out of the investment on the other [23]. A challenge is that the balancing opaquely carries on several social, socioeconomic, political, and even environmental implications bringing up concerns such as practicality and political reality to calling into question whether ALARP is mainly theoretical [23].

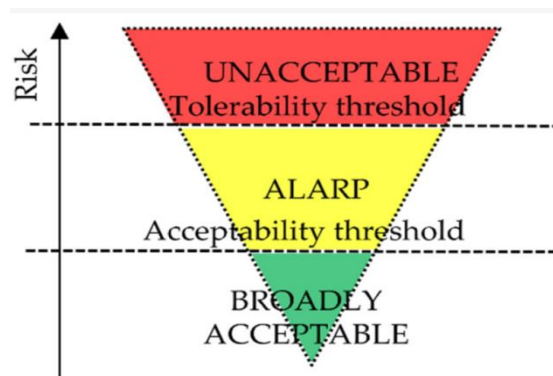


Figure 1: The ALARP Principle.

Ethical strengths of ALARP in HSE Decision-making

While there are ethical challenges with the use of the ALARP principles, the continued use of the principle is anchored on some ethical strengths as a core HSE decision-making tool. A key strength of ALARP, as [24] noted, is its proportionality and optimization. With ALARP principle, there is proportional approach to risk mitigation, thus decision-makers are encouraged to balance the benefits of risk reduction against financial, technical, or temporal sacrifices required to avoid both under-regulation and excessive conservatism [24]. This approach aligns with the ethical proposition and utilitarian ideals of maximizing overall well-being while conserving limited resources [25].

Another ethical strength of ALARP that some researchers assert to is in the area of accountability and transparency. The ALARP principle demands that decisions to accept residual risk need to be clearly justified through CBA or safety case documentation. Such justification aligns with the requirements of procedural ethics and ensures that decisions are traceable and can be justified to regulators, workers, and the public [26]. Such approach enhances public trust by showing that risk acceptability is not arbitrary but based on reasoned justification, transparent process, and verifiable data [24].

The ALARP principle in some contexts abides with the ethical principle of justice and non-discrimination [26]. Typically, the principle does not support exposure of any individual or group, particularly vulnerable populations, to avoidable and unjustifiable risks, aligning with the principles of distributive and environmental justice [26]. For instance, as [27] noted, even when the risks might be legally tolerable, ALARP requires employers to reduce employees exposure to carcinogens or noise pollution, if further reduction is reasonably practicable by promoting a culture of continuous improvement and improved precautionary measures through ongoing evaluation of new technologies, methods, and insights to drive improved HSE outcomes. Such dynamic approach encourages ethical foresight and moral responsibility in dynamic industrial contexts.

ALARP principle also drives systems thinking and moral responsibility, thus prompting practitioners to consider cascading impacts, human-machine interactions, and unintended consequences [27]. Such holistic approach aligns with modern ethical frameworks that emphasize moral responsibility beyond isolated or mere focus on risk metrics.

Generally, while there are concerns on ethical drawbacks of the ALARP principles, the principle has strengths not only in its practicality but also in its ethical structure of driving fairness, transparency, accountability, and the responsible use of limited HSE resources.

Ethical Weakness of the Concept of ALARP in HSE Decision-Making

While the value of assets can be financially quantified, quantifying the value of human life, injury, or environmental excursion can be challenging. For instance, it may be difficult to quantify the number of people impacted by a fatality or injury at work. Even when the person directly involved is single, there are chains of people connected to the single person that limiting the impact and quantifying the implication may be challenging. Unlike the focus on quantitative data which is what is often obtainable in CBA, as [4] noted, it is not all costs and benefits that can be easily quantified, or translated into monetary form. However, certain qualitative descriptions of the pros and cons associated with a contemplated action in relation to HSE can offer helpful insights in decision making thus bridging the gap that may be lacking in the sole reliance on quantitative data [4].

According to [4], “The growing impact of regulations on the economy has led both Congress and the administration to search for new ways of reforming regulation. Many of those regulatory reform initiatives call for greater reliance on the use of economic analysis in the development and evaluation of regulations. Because ideological extremes have dominated debate on this topic, a dispassionate commentary may be particularly valuable.” The puzzle is where to place HSE in the use of economic analysis in the development and evaluation of regulations. Is it ethically acceptable to hurt people so far as it offers economic benefits?

With the concept of ALARP, a risk is considered acceptable if the costs to mitigate it are disproportionate to the benefits obtainable [28]. Though the consequences of hazard exposures include negative impacts on people, environment, assets, and reputation [29], the benefits considered during ALARP analysis are typically in terms of economic value. This, therefore, raises the question whether it is ethically justifiable to accept a condition that can injure someone or pollute the environment on the premise that the costs to mitigate it are disproportionate to the expected financial benefits. The ALARP principle, therefore, violates deontological ethics which emphasizes duties of care and protection for humans.

As [21] noted, there are some areas of concern about the validity of ALARP as a risk management principle. These include representativeness, morality, philosophy, political reality, and practicality [21]. While many industry experts accept ALARP and utilize the concept in facility designs, risk evaluation during hazard and operability studies (HAZOP), a key, and in some contexts fundamental, difficulty is that the adoption of ALARP as a risk acceptance criteria is not open to public scrutiny and “appear to be settled by negotiation with proponents of ‘risky’ ventures” [21]. The implication is that the workers and public, who may be victims of residual risks accepted in line with the ALARP concept, are not part of the decision making and do not have the opportunity to indicate their concurrence with the risk acceptance criteria. ALARP concept, therefore, begs the question if it is ethically right for someone to accept what may hurt another on the mere premise that the risk was reduced to as low as reasonably practicable relying on economic basis even though there were options of complete eliminations of the risk.

The ALARP approach portrays the balance of safety, economy, and environmental friendliness [30]. With this approach, it seems that price tags are applied to hurts and environmental impacts and the price tags of certain hurts and environmental exposures are accepted as economically viable. Since the ALARP concept is not prescriptive and rather emphasizes self-evaluation, risk-orientation and balance of all aspects [30], it gives room for subjectivity, hence the potential for decision making that may sacrifice the safety of personnel and environmental protection for financial benefits. The ALARP principle, therefore, faces the ethical challenge of integrity which emphasizes honesty, truthfulness, earnestness of one’s action, and internal consistency against decisions based on conflicting values.

With increasing modernization of safety ecosystems due to impacts of automation, artificial intelligence (AI), wearable technologies, and interconnected systems, the concerns about the utility and ethical complexity of ALARP-based decision-making in HSE has increased. Lately, many risk assessment frameworks increasingly rely on algorithmic models to quantify cost-effective risk reduction measures, thus introducing new ethical dimensions into what was previously an engineering and economic evaluation. According to [9] and [31], the algorithmic elements often contain subjectivity and bias, particularly due to opaque data practices and modeling assumptions. Sharing their perspective on subjectivity of ALARP decision, [32] and [33] noted that such terms as “as reasonably practicable” and “gross disproportion” are inherently subjective, allowing broad interpretation that may lead to inconsistent or biased risk decisions. The implication is that the flexibility can give room for organizations to justify minimal HSE efforts as compliant, potentially undermining workers and environmental protection [32][33].

Moreover, with AI systems, it is challenging to determine what is considered “reasonably practicable” due to the lack of transparency inherent in “black-box” [34]. This, therefore, undermines the traceability of decisions made [34]. The integration of AI also necessitates novel forms of stakeholders engagement, especially in the light of the concerns surrounding data privacy and ethical consent in workplace surveillance systems [35]. The implication is that there is the potential for the systems to exacerbate justice and equity concerns, particularly if or when AI surveillance tools disproportionately target marginalized workers or communities [36]. Thus, the technological systems used for ALARP decisions may not align with the ethical expectation of technical normality by embedding values and norms in the systems.

Another challenge with the adoption of ALARP principle is the fragmentation of decision-making authority. This makes responsibilities for decisions to be spread across multi-functional components of technical, organizational, and algorithmic actors. The implication is the complication of accountability, hence the challenge in assigning moral or legal responsibility for HSE outcomes [9] [37].

Another ethical challenge of the ALARP principle is its reliance on cost–benefit analysis which implies attaching monetary values to health, life, and the environment. Scholars argue that this approach turns HSE into a commodity, effectively neglecting the dignity of man and human rights [38][39]. The ethical challenge is more pronounced when low-income, vulnerable, or marginalized groups, whose lives may be considered of less value in cost-benefit metrics, bear disproportionate risks [38][39]. Similarly, HSE decision based on ALARP principle can disproportionately affect vulnerable populations since they may be marginalized and denied safety investment on the premise of perceived lower benefit-to-cost ratios, reinforcing structural societal injustice instead of challenging it [38][40]. The ALARP principle, therefore, is contrary to the ethical principle of distributive justice which emphasizes reasonable share of material goods, opportunities and social advantages and addresses inequalities to promote a just distribution of societal benefits.

Another ethical concern with the ALARP principle is in the area of transparency and accountability for decisions. As [33] and [39] observed, cost–benefit justifications within ALARP are often buried in technical documents, with limited visibility and accessibility to the workers or communities that may be impacted by the ALARP decisions. The implication is the potential for impaired accountability and degraded trust, particularly if the rationale for forgone HSE actions is technical or economic rather than workers or environmental protection [33][39].

Another challenge with ALARP decision is the potential for overconfidence in quantification and technocracy. Uncontrolled quantitative focus may trigger technocratic overconfidence, at the expense of qualitative elements such as human error, organizational culture, or emerging hazards [32][40]. Such limited view of required HSE actions can lull organizations into false assurances, even when complex real-world factors have not been addressed [32][40].

In the light of the weaknesses of the ALARP principle as an HSE decision making tool, the validity of ALARP principle as a flexible cost–benefit framework that can withstand the ethical scrutiny required by modern, automated, and interconnected HSE systems is in question. Therefore, as [31][35] noted, unless ALARP principle is reinforced with ethical clarity, procedural fairness, and inclusive stakeholder participation, it lacks the ethical basis to fulfill its moral and regulatory purpose in contemporary contexts.

III. Conclusion

The ALARP principle is frequently used as an HSE decision making tool. Though there are concerns on ethical drawbacks of the principle, the principle has strengths not only in its practicality but also in its ethical structure of driving fairness, transparency, accountability, and the responsible use of limited HSE resources. However, while the concept of ALARP aligns with the utilitarian ethical principle of maximizing overall safety impact per cost unit, it seems to commodify human life and environmental protection. Also, the ALARP principle relies heavily on CBA and so conflicts with deontological ethics which emphasizes duties to protect individuals. With ALARP mindset, it is possible for the duty of care to be neglected on the basis of mere cost-benefit trade-offs. Also, though the ALARP principle generally aligns with virtue ethics which emphasize the moral character of decision-makers - transparency, integrity, responsibility - the the challenge of visibility and accessibility of ALARP decision documents, lack of involvement of all stakeholders in decision making and the contemporary reliance on technology such as automation and AI raises questions about ALARP's ethical viability Finally, while the ALARP concept does not support exposure of any individual or group, particularly vulnerable populations, to avoidable and unjustifiable risks, the use of economic variables in ALARP decision may result in marginalizing and denying safety investment to protect certain people on the premise of perceived lower benefit-to-cost ratios, raising ethical challenge of inequitable distribution of risks and benefits and sidelining vulnerable groups.

IV. Recommendations

ALARP principle provides necessary flexibility for decision making but needs ethical reinforcement. The principle should be revised to include ethical clarity, process transparency, and attention to fairness. Regulatory agencies, professionals, and ethicists should collaborate to enhance ALARP's framework by integrating ethical tools alongside technical risk assessment to enhance more moral and equitable safety decisions.

As [6] noted, though cost-benefit analysis should form a key part of the considerations for agency and regulatory decisions, decision makers should not be strictly bound by it. In the events that the cost appears to be more than the benefit, the responsible person “should be required to consider available benefit-cost analyses and to justify the reasons for their decision in the event that the expected costs of a regulation far exceed the expected benefits.” While ALARP may be suitable in areas where safety of personnel and environmental protection are involved, in contexts where decision-making involves accepting certain residual residual risks with potential safety and environment exposures, the consent of those that may be impacted by the residual risk should be sought before a risk can be accepted on the basis of ALARP.

With increasing automation of decision, ethical considerations should be part of the algorithm when HSE decision is automated or rely on AI. Stakeholders should be part of the review of the ethical inputs to the algorithm.

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