The precautionary principle has no exceptions

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1. Introduction

The *absolutist* interpretation of the precautionary principle states that any action with a nonnegligible potential for a catastrophic outcome should be avoided, regardless of its benefits, even in the presence of considerable scientific uncertainty about the magnitude and likelihood of the catastrophe.[1] In contrast, *non-absolutist* interpretations take the precautionary principle to be one of several prima facie principles that must be balanced against others.[2]

In an earlier paper, written when I was a young postdoctoral researcher benefiting from extensive and fruitful discussions with Nils-Eric Sahlin, I demonstrated that a wide range of absolutist interpretations of the precautionary principle are incompatible with a set of basic conditions for rational choice.[3] Other scholars later expanded on this criticism, and the most comprehensive and technically sophisticated contribution I am aware of is by Orri Stefánsson.[4] In the current contribution, I will present two new impossibility results for the precautionary principle that are independent of my earlier work.[5]

The first impossibility result explores whether the precautionary principle could be made less demanding and, therefore, more plausible by allowing for exceptions. Consider, for instance, the suggestion that acts carrying a non-negligible potential for a catastrophic outcome should always be avoided whenever possible, *except* when doing so would be extremely costly. I will demonstrate that all absolute versions of the precautionary principle that allow for exceptions are incompatible with certain fundamental conditions for reasonable decision rules. This is a more

general point than the one I made in my original paper because it applies to a wider class of formulations of the precautionary principle.

The second impossibility result builds on Kenneth Arrow's well-known impossibility theorem in social choice theory.[6] My point is that if we interpret the precautionary principle as a prima facie principle to be balanced against other prima facie principles, then no method of aggregating such principles can meet a set of plausible conditions that mimic Arrow's conditions for social welfare functions. Because this result does not assume that it is sometimes appropriate to make exceptions to the precautionary principle, it is quite general in scope.

2. An example: The water crisis in Flint, Michigan

Why might it be appealing to allow exceptions to the precautionary principle? The Flint water crisis serves as a compelling illustration, even though the precautionary principle does not play any official role in US drinking water regulations.[7]

In April 2014, the City of Flint ceased purchasing drinking water from the water plant operated by the nearby City of Detroit.[8] To save money, Flint restarted its own water plant, built in 1954, which draws raw water from the heavily polluted Flint River.[9] Soon after the switch, residents began to complain about the smell and taste of the water. To address these concerns, the City invited a large engineering firm to review the city's water treatment process in February and March 2015. The company sent two consulting engineers to Flint, who spent about two weeks in the city. In the final report submitted in March 2015, the consulting engineers made ten recommendations, including a recommendation to "Contract with your engineer and initiate discussions with the State [of Michigan] on the addition of a corrosion control chemical."[10]

A few months later, concerns were raised about high lead levels in the drinking water. Corrosion initiated by the change in water chemistry was believed to be the root cause, but experts disagreed on how severe the lead issue was. Flint switched back to Detroit water in October 2016, and the Governor of Michigan apologized to the residents. In one of the many lawsuits that followed, the government was ordered to pay $626 million in damages to 90,000 Flint residents. Five government officials resigned or were fired, and two were charged with involuntary man-

slaughter. In a separate class action lawsuit, plaintiffs alleged that the consulting engineers had failed to give appropriate professional advice to the City of Flint.

Although the precautionary principle played no role in the Flint water crisis, and no regulatory document required the City to apply it, advocates of the precautionary principle will likely argue that it would have been appropriate to invoke it: Was the switch of raw water source compatible with the precautionary principle given the uncertainties about the new water chemistry? Should the City have immediately switched back to Detroit water when the problems occurred? Should all lead pipes have been replaced when the water chemistry changed, including all privately owned service lines? And so on.

By permitting the precautionary principle to have exceptions, we could make it less demanding and less vulnerable to counterexamples. For example, rather than concluding that a change in raw water source is *never* permitted unless *all* uncertainties are eliminated, it might be reasonable to permit exceptions if the cost savings are substantial. Similarly, instead of interpreting the precautionary principle to require the replacement of virtually *all* lead pipes nationwide, including privately owned service lines, exceptions could be made for well-functioning water systems where such replacements are prohibitively expensive.

All these examples suggest that it is worthwhile to explore whether the precautionary principle could reasonably be allowed to have exceptions. In the next couple of sections, I will use formal methods to substantiate a negative answer.

3. The absolutist interpretation

Numerous precisifications of the precautionary principle have been proposed in the literature. If we interpret the precautionary principle as an absolutist principle, then a risky option y that meets the applicable criterion for invoking the precautionary principle will always be ranked below some other option x if the latter does not meet said criterion. This is not the only possible definition of the term "absolutism". For instance, André Nollkaemper writes that:

> In several treaties, the precautionary principle is formulated in absolutist terms. It stipulates that once a risk of a certain magnitude is *identified*, preventive measures to erase that risk are *mandatory*.[11]

I agree with Nollkaemper that many policymakers formulate the precautionary principle in this manner. However, Nollkaemper's notion of absolutism is much stronger than the one I propose. I do not take absolutism to entail that once a risk of a certain magnitude has been *identified*, then preventive measures to erase the risk are *mandatory*. My definition leaves it open what level of uncertainty and magnitude of catastrophic outcome is required for invoking the precautionary principle.

We can model the notion of absolutism I propose by assuming that the pairwise ranking of the relevant options *remains the same in all choice situations, regardless of the other principles* included in the analysis. This means that if y (an option associated with a risk that warrants precautionary measures) is ranked below x (an option that does not do so) in some option set, then x is ranked above y in *all* option sets.

For the purposes of this paper, choice situations can be identified with the options available to the agent: $A = \{a, b,\ldots\}$ is the choice situation in which a, b,… are available, and so on. A decision rule is a function that takes the set of all choice situations $S = \{A, B,\ldots\}$ as its argument and ranks the options in each choice situation. The formula $x >_P^A y$ means that x is ranked as strictly better than y according to principle P in choice situation A. There is no need to assume that the ranking is complete.

Let $>^A$ (without lower index) denote the all-things-considered ranking in choice situation A derived from some absolutist or non-absolutist principles $x >_P^A$, $x >_Q^A$,… Because absolutist principles do not have to be balanced against other principles, if P is an absolutist principle, the formula $x >_P^A y$ guarantees that $x >^A y$, and in every other option set B that includes x and y as elements, it also holds that $x >^B y$. If P had been a mid-level or prima facie principle, none of this would have followed. Non-absolutist principles take the ranking of an option to depend on additional principles, meaning that nothing can be inferred about the all-things-considered ranking from a single mid-level or prima facie principle. Formally, if P is a mid-level or prima facie principle, the formula $x >_P^A y$ does not reveal any information about the all-things-considered ranking in any option set.

Consider the following formal definition:

> *Definition of Absolutist Precautionary Principle:* P is an absolutist precautionary principle just in case, for every option set A and every x and y, if $x >_P^A y$ then $x >^B y$ for every B that includes x and y as elements.

This notion of absolutism is inspired by how moral philosophers use the term. As explained by Frank Jackson and Michael Smith, the key characteristic of an absolutist moral principle is that it absolutely prohibits actions of a special kind K, where "K may be promise breaking (as in Kant), intentionally killing the innocent (as in some Catholic ethical theory)", and so on.[12] If act x is, say, the breaking of a promise and y is not, then Kantians will always rank y above x regardless of what other options are available. The same goes for the choice between intentionally killing the innocent and not doing so, and my proposal is that we think of absolutism in discussions of the precautionary principle in the same way.

4. Are exceptions possible?

Few people believe that action-guiding principles ought to be absolutist in the sense outlined in the preceding section. Promises must not *always* be kept, and lying is not *always* wrong. And in exceptional cases, it may even be permissible to kill an innocent person if this is necessary to save many more innocent people. Similar exceptions may also apply to the precautionary principle. Suppose the precautionary principle requires us to, for example, replace old lead pipes or lower the action level of the United States Environmental Protection Agency (EPA) for lead in drinking water. In that case, a reasonable version of the precautionary principle must not entail that we are required to do so *without exception*. If the cost of a precautionary measure is exceptionally high or some other relevant circumstances obtain, exceptions would surely be appropriate. For the purposes of this paper, there is no need to specify precisely under what circumstances such exceptions apply; all that matters is that some acts are, under some suitably specified conditions, excepted.

The claim that the precautionary principle has exceptions is best expressed by restricting the set of options to which it is applicable.

Let $>_P^{A-X}$ denote the ranking of principle P applied to all options in the option set A except the subset X. If the precautionary principle has exceptions, those exceptions have to be evaluated by some other principle, such as the cost-benefit principle or the ALARA (As Low As Reasonably Achievable) principle. A system of policy principles that includes an absolutist version of the precautionary principle that permits exceptions will thus have at least two elements: the precautionary principle, which does not apply to some non-empty set of exceptions X, and some other principle Q that ranks the elements of X. Consider the following formal definition:

> *Exceptions to the Precautionary Principle (EPP):* There exists an absolute principle P with exceptions X such that if $a, b \notin X$ and $a >_P^{A-X} b$, then (i) for every choice situation B that includes a and b as elements it holds that $a >^B b$, and (ii) there exists some other (absolute or non-absolute) principle Q that ranks the elements of X in A.

This seemingly plausible version of the precautionary principle is incompatible with three fundamental conditions on rational choice:

> *Strict Dominance (SD):* If every principle R applicable to A ranks $a >_R^A b$, then $a >^A b$.

The SD condition is required for handling cases with three or more policy principles. For systems with just two principles, it can be dropped. The remaining pair of conditions assert that the all-things-considered ranking must be transitive, and that every logically possible choice situation can be evaluated:

> *Transitivity (TR):* For every choice situation A, if $a >^A b$ and $b >^A c$, then $a >^A c$.

> *Unrestricted Domain (UD):* All logically possible choice situations can be evaluated by the policy principles adopted by the decision-maker.

The conditions stated above entail the following impossibility result:

The First Impossibility Result: Conditions *EPP*, *SD*, *TR*, and *UD* are incompatible in every choice situation that has at least three differently ranked options.

The proof is straightforward:[13] Consider an absolute principle *P* that has some exceptions *X* and another principle *Q* that is applicable to *X*. Condition *UD* guarantees that there exists a choice situation A = {a, b, c, d} in which all applicable principles *R* (including *P* and *Q*, if applicable) rank $d >_R^A a$ and $b >_R^A c$. We assume that the choice situation is chosen such that *P*'s ranking is $a >_P^{A-X} b$, but the exceptions c, $d^{\notin X}$ are handled by *Q*, which ranks $c >_Q^A d$. *EPP* now guarantees that because $a >_P^{A-X} b$, it holds that $a >^A b$. Moreover, because of clause (ii) of *EPP*, $c >_Q^X d$ guarantees that $c >^A d$, and *SD* entails that $d >^A a$ and $b >^A c$. By putting these rankings together, we find that $d >^A a >^A b >^A c >^A d$, which violates *TR*.

So far, we have assumed that *a*, *b*, *c*, and *d* are distinct options, but it was noted earlier that only three options are required. To see why, consider the case in which *a*, *b* and *c*, *d* have one element in common. Suppose, for instance, that *a* = *c* and imagine that the choice situation *A* is such that all applicable principles *R* rank $b >_R^A d$. Let *P*'s ranking include $a >_P^A b$ but let *c* and *d* be excepted from the ranking. The exception is handled by *Q*, which ranks $d >_Q^A c\ (= a)$. *EPP* entails that $a >^A b$ and $d >^A c$. Because *c* = *a*, we have $d >^A a$. However, *SD* entails that $b >^A d$. It follows that $a >^A b >^A d >^A a$, which contradicts *TR*. The other cases, in which *a* = *d*, or *b* = *c* or *d*, are analogous.

5. No exceptions in Flint

This section discusses the first impossibility result within the context of the Flint water crisis. As emphasized in the preceding section, this result hinges on the assumption that the precautionary principle is interpreted as an absolutist principle. The second impossibility result, applicable to non-absolutist interpretations, will be explored in the next section.

In October 2024, the United States government under President Joe Biden announced that the EPA would lower the "action level" for lead in drinking water—the threshold triggering mandatory safety measures—from 15 to 10 parts per billion (ppb). A suggestion to lower the action level to 0 ppb, which would have squared well with the precautionary

principle, was dismissed as excessively expensive. It was furthermore announced that lead pipes owned by water utilities but not privately owned service lines will have to be replaced in the next ten years at a cost of approximately $20 billion.

The Biden administration's decision was based on a cost-benefit analysis that indicated the benefits outweighed the costs.[14] However, the scientific uncertainties are significant. The benefits listed in the analysis include the prevention of ADHD in 2,600 children and the annual loss of 200,000 IQ points in children. These numbers are rough estimates, as is the attempt to translate them into monetary benefits. According to the EPA, the estimated total benefits are worth $130 to $250 billion over 10 years, and the estimated cost $15 to $20 billion. Critics, however, argue that the cost will be significantly higher and the associated benefits will be substantially smaller.[15]

The upside of relying on the precautionary principle instead of cost-benefit analysis is that the former does not force us to quantify costs and benefits, meaning that the conclusion would be less uncertain. As long as the potential for a sufficiently bad outcome is nonnegligible, eliminating lead pipes and reducing the action level it is always better. The following statement summarizes the policy endorsed by the EPA in 2024:

> *a:* Replace the vast majority of service lines and lower the EPA threshold to 10 ppb for $20 billion.

This formulation does not explicitly mention the benefits; however, if we seek to apply the precautionary principle, there is no need to weigh costs against benefits. It suffices to identify a nonnegligible, potentially catastrophic risk that could be eliminated by taking some precautionary measure—in this example, replacing the vast majority of service lines and lowering the EPA threshold to 10 ppb.

It is instructive to compare option *a* to three further options that EPA could have chosen but did not actually choose. The costs listed below are rough estimates included for illustrative purposes:

> *b:* Replace the vast majority of service lines but keep the EPA threshold at 15 ppb for $15 billion.

c: Do nothing: keep all lead pipes and keep the EPA threshold at 15 ppb for $0.

d: Replace all lead pipes and lower the EPA threshold to 0 ppb for $50 billion.

Suppose the precautionary principle is applicable to every choice between two or more policies that impact the safety of drinking water, *except* when the difference in cost is at least $50 billion. Clearly, *a* is better than *b* according to the precautionary principle because of the lower action level, and *b* is likewise better than *c* according to the precautionary principle. However, the precautionary principle does not apply to the choice between *c* and *d* because the cost of *d* is $50 billion. Here, we need to apply some other principle. Suppose we choose the cost-benefit principle and conclude that *c* is better than *d*. (The *UD* condition guarantees that some choice situation of this type is possible; the example considered here is just an illustration.) Finally, we apply the precautionary principle to the choice between *d* and *a*, which we can do because the difference in cost is less than $50 billion, and conclude that *d* is better than *a*. Hence, the all-things-considered ranking is $d >^A a >^A b >^A c >^A d$, which contradicts TR.

6. The second impossibility result

The second impossibility result targets the idea of interpreting the precautionary principle as a prima facie principle. According to W. D. Ross, "right acts can be distinguished from wrong acts only as being those which, of all those possible for the agent in the circumstances, have the greatest balance of prima facie rightness".[16]

My goal in this section is to show that a version of Arrow's well-known impossibility theorem is applicable to the aggregation of prima facie principles: no rule for calculating the overall balance of prima facie rightness can satisfy a set of conditions stated below, provided that the number of prima facie principles is finite but greater than one, and if at least three options are available to the agent. This point is applicable to *every* set of prima facie principles; it does not only target the precautionary principle.

Each prima facie principle, including the precautionary principle, ranks a finite set of options $A = \{a, b, \ldots\}$ with respect to prima facie rightness. The formula $a >_i b$ means that a is more prima facie right than b with respect to prima facie principle i, and $a > b$ (without index) means that the overall balance of prima facie rightness of a is greater than that of b. An option is right all things considered (or *sans phrase*, as Ross put it) if no other option has a higher balance of prima facie rightness. Consider the following conditions:

> *Ordering:* The overall ranking of prima facie rightness is complete and transitive.
>
> *Independence of Irrelevant Alternatives:* The pairwise ranking of a and b must not depend on whether some third option c is available.[17]

In order to state the remaining conditions, it is helpful to use a technical term invented by Amartya Sen:[18]

> *Definition:* A set of prima facie principles D (it can be a singleton set) that is a subset of the set of all prima facie principles G is *decisive with respect to* the ordered pair (a, b) if and only if $a > b$ whenever every prima facie principle i in D ranks $a >_i b$. A set of prima facie principles is *decisive* just in case it is decisive with respect to all pairs of options.

The remaining conditions and the impossibility result can now be stated as follows:

> *Dominance:* The set of all prima facie principles G is decisive.
>
> *No Dictatorship:* No single prima facie principle (i.e., no singleton set D) in G is decisive.
>
> *The second impossibility result:* If the number of prima facie principles is finite but greater than one, and the number of distinct options is at least three, then no rule for aggregating prima facie principles satisfies the following conditions: Ordering, Independence of Irrelevant Alternatives, Dominance, and No Dictatorship.

The proof is analogous to Sen's simplified proof of the original version of Arrow's theorem and will not be reproduced here.[19] It is merely the interpretation that is novel. The relevance of this result depends on what other prima facie principles we wish to combine with the precautionary principle. Note that *all* prima facie principles must satisfy the conditions for the result to hold.

Independence of Irrelevant Alternatives is often considered controversial in social choice theory. Consider the following counterexample discussed by Sen:[20] There are two oranges and a kiwi left in a fruit bowl. If I take one of the oranges, you will get to choose between two different types of fruits, an orange, and a kiwi, once it is your turn to pick a fruit. So, because I am a polite person, it seems rationally permissible for me to pick an orange if all three fruits are available, but if there is only a single orange and a kiwi left, the only rationally permissible option is to pick the kiwi, because that is the fruit I like the most. In that case, my desire to leave you with a choice is no longer relevant. Sen's point is that these preferences violate Arrow's original version of Independence of Irrelevant Alternatives because the preference between the kiwi and the first orange depends on an "irrelevant" alternative: the availability of the second orange.

Is this counterexample applicable, mutatis mutandis, to prima facie principles? For many plausible prima facie principles, the answer seems to be no. Consider, for instance, a prima facie principle requiring policymakers to be truthful and honest. That principle is not sensitive to "irrelevant" options because the agent is either truthful and honest or not. The requirement to be truthful and honest does not depend on the availability of other options. A similar point is applicable to the prima facie precautionary principle: if some option is impermissible to choose, at least prima facie, because it is too risky and uncertain, then this is so regardless of what other options are available.

Note that Independence of Irrelevant Alternatives is not a claim about individual prima facie principles but about the aggregation of prima facie principles. My suggestion is that if no individual prima facie principle is sensitive to relational properties (such as being the only option of a certain type), then a plausible aggregation rule should also be insensitive to such properties. This suggests that for many sets of policy principles holding prima facie, including the prima facie precautionary principle, Arrow's cannot be easily refuted.

7. Conclusion

The impossibility results outlined in this paper present a challenge for defenders of the precautionary principle. The first impossibility result shows that it is not attractive to interpret the precautionary principle as an absolute principle that allows for exceptions. The second result demonstrates that we cannot regard it as a prima facie principle. The only viable action guiding interpretation seems to be to interpret it as an absolute principle that does not permit any exceptions—but that would reintroduce the impossibility results that motivated me to write this paper. My overall conclusion is that it is more attractive to interpret the precautionary principle as a belief-guiding principle for addressing epistemic risks.[21]

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Notes

1. See Steel 2015 for an overview. See also Sandin *et al*. 2002.

2. A third, in my opinion, highly plausible interpretation is to read the precautionary principle as an epistemic principle designed to guide our beliefs; see Peterson 2007. This interpretation is inspired by N.-E. Sahlin's notion of epistemic risk; see, e.g., Sahlin 1983; Sahlin & Persson 1994.

3. Peterson 2006; Peterson 2017a.

4. Stefánsson 2019; see also Boyer-Kassem 2017.

5. The first formal result is structurally similar to Amartya Sen's observation that a particular way of defining rights in social choice theory is incompatible with the Pareto principle; see Sen 1970. The formal analysis in sections 3 and 4 of this paper draws heavily on my working paper 'Can absolute moral principles have exceptions?' Peterson 2024a. The second formal result is structurally similar to Kenneth J. Arrow's (1951) famous impossibility result. My adaptation draws partly on Peterson 2024b.

6. Arrow 1951.

7. Full disclosure: I have served as an expert witness for defendants in several lawsuits related to the Flint water crisis, for which I have been financially compensated.

8. For approximately four years, until spring 2024, I was retained as an expert witness on engineering ethics in a class action lawsuit related to the Flint water crisis. The suit ended with a $25 million settlement in February 2024 and I was then relieved of my duties. The opinions expressed in this paper are my own and are not intended to have any bearing on legal issues.

9. The National Resource Defense Council (2025) writes that "For more than a century, the Flint River, which flows through the heart of town, has served as an unofficial waste disposal site for treated and untreated refuse from the many local industries that have sprouted along its shores, from carriage and car factories to meatpacking plants and lumber and paper mills."

10. Veolia North America 2015.

11. Nollkaemper 1996, p. 73.

12. Jackson and Smith 2006 (p. 267) discuss whether absolutist principles can be applied to risky actions in a reasonable manner. This is a topic I will not discuss here.

13. As noted earlier, the proof is similar to Amartya Sen's (1970) observation that a certain way of defining rights in social choice theory is incompatible with the Pareto principle; see also Peterson 2017b, ch. 13.

14. EPA 2024.

15. Samson *et al*. 2024.

16. Ross 1930, p. 45; italics removed. Ross is careful to point out that the term "prima facie" is somewhat misleading because it suggests that "one is speaking only of an appearance which a moral situation presents at first sight, and which may turn out to be illusory; whereas what I am speaking of is an objective fact involved in the nature of the situation" (1930, p. 20).

17. See Ray 1973 for a discussion of different technical versions of this condition.

18. Sen 1995.

19. See Sen 1995, p. 4, n. 9.

20. Sen 1995.

21. Peterson 2007. See also Sahlin 1983 and Sahlin & Peterson 1994 for thoughtful discussions of the notion of epistemic risk.

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