Increasing preparedness for extreme events using plausibility-based scenario planning: Lessons from COVID-19

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Abstract

A striking feature of COVID-19 is many countries' low level of preparedness for it, despite pandemics being a known threat. This raises a question as to the reasons for this under-preparedness. While preparedness should have better reflected pandemics' long-run inevitability and potentially catastrophic impact, government-planning horizons are short term, and the attentiveness of policy-makers is bounded and subject to multiple demands. Preparedness is therefore affected by the fundamental uncertainty surrounding the exact nature, timing, and impact of a pandemic. While a subjective probability is attributable to such an event's occurrence, just like it is any other, if founded on scant knowledge and perceived as being low it may inhibit preparedness. Under such circumstances, preparedness may be better served by a focus on plausibility. Moreover, any tendency for policy-makers to disregard highly-uncertain, low-probability, yet highly-impactful events of this type is exacerbated by their 'fat-tailed' distribution, which obscures their potential extremity. This paper considers how plausibility-based scenario planning can increase preparedness for extreme events like a global pandemic, thereby reducing overconfidence in continued business-as-usual in their face, and emphasising precaution in their wake. In so doing, the paper contributes to what in this journal has recently been called 'type B', 'generic and fundamental' risk science, which is concerned with identifying better ways to present and communicate uncertainties. In focusing on plausibility-based scenario planning, the paper highlights a method seldom previously discussed in relation to risk science, yet one that can contribute much to this type B component of it.

Key words: preparedness; scenario planning; precautionary principle

1. INTRODUCTION

A striking feature of COVID-19 is many countries' low level of preparedness for it (Balog-Way & McComas, 2020) despite pandemics being a known threat, as highlighted in the Global Risks Report annually. Indeed, the threat from pandemics featured prominently in the 2019 Global Risks Report (WEF, 2019), published less than a year before the initial COVID-19 outbreak. That report suggested pandemics are increasing in frequency and severity, and that the world is 'badly under-prepared' for them (WEF, 2019, p.46). A pandemic was therefore a known threat, for which many countries could have better prepared. The reasons they did not is the topic of this paper, which considers the role of plausibility-based scenario planning in increasing preparedness for such events. While undoubtedly multifaceted in nature, part of the explanation for this under-preparedness is argued to be the fundamental uncertainty surrounding the exact nature, timing, and impact of a pandemic. It is also argued to relate to their 'fat-tailed' distribution, which obscures their potential extremity (Cirillo & Taleb, 2020).

Policy-makers tend anyway to underestimate extreme and rare events' probability and potentially-devastating scale (Wright & Goodwin, 2009; Goodwin & Wright, 2010). However, this tendency is further exacerbated by such events' 'fat-tailed' probability distribution, which implies a greater frequency for extreme occurrences than does a more standard probability distribution (Taleb, 2020; Cirillo & Taleb, 2020). In plausibility-based scenario planning, participants create narratives describing the unfolding of causal sequences that give rise to extreme outcomes. Firstly, this may increase the perceived probability of a considered extreme outcome, thus rendering it more congruent with the increased frequency implied by a fat-tailed probability distribution, and thus stimulating greater preparedness for it (Schoemaker, 1993; Kuhn & Sniezek, 1996). Secondly, it can increase awareness of the full range of possible outcomes from extreme events (Kuhn & Sniezek, 1996, p.245), thus aiding realisation of the need for precaution in their wake.

Preventing harm requires if-then conditional thinking (i.e., if x then y) that is able to deal with contingency, rather than prediction based on present knowledge (Seligman et al., 2013). Plausibility-based scenarios do not attempt to predict what *will* happen (Urueña, 2019). They are designed to explore what could *plausibly* happen and to change the future by stimulating actions that can negate an undesirable outcome. Using plausibility as a criterion for selecting the possibilities on which to focus, in combination with other criteria such as desirability, opens up to consideration a broader range of possibilities than a probabilistic analysis (Urueña, 2019). What is plausible is a matter of interpretation and negotiation within the context of a given temporal, spatial and causal framework (Urueña, 2019). Statistical background information, such as trends and past outturns, *is* included in assessing the plausibility of alternative views on what might reasonably happen, but a scenario's plausibility is not entirely dependent on them in the way it would be in a probabilistic analysis (Urueña, 2019). Extremes way beyond past outturns may be deemed plausible if the causal framework and context under consideration is conducive to their occurrence.

Yet, despite its usefulness in these regards, and its relevance to the subject matter of this journal, discussion of plausibility-based scenario planning has thus far been absent herein. This contrasts with the attention devoted to probability- and modelling-based scenario planning, which has been discussed extensively (e.g. Tosoni et al., 2018; Freira et al., 2015; Thekdi & Santos, 2016). This paper begins to address this omission by broaching the subject of plausibility-based scenario planning herein for the first time. It also discusses, for the first time in *any* forum, the role of plausibility-based scenario planning in precautionary decision-making. In so doing, the paper contributes to what Aven (2020, p.1889) calls 'type B', 'generic and fundamental' risk science, which is concerned with identifying better ways to present and communicate uncertainties.

2. PLAUSIBILITY-BASED SCENARIO PLANNING AS AN AID TO PREPAREDNESS

A central problem giving rise to many countries' seemingly low level of preparedness for COVID-19 is policy-makers' insufficient attentiveness to highly-uncertain, low-probability, yet potentially highly-impactful events (Wright & Goodwin, 2009). While the aggregate risk of a severe pandemic merges with unity over the long run, and they are therefore inevitable *at some point*, over any relatively short government-planning period, their probability is quite low. Moreover, a pandemic's exact timing, nature, and impact are fundamentally uncertain in any one instance. As a result, while a subjective probability may be attributable to their occurrence, there would be considerable potential to assign it an extremely low probability, or even a probability of zero (Wright & Goodwin, 2009, p.814).

Moreover, even if awareness of such an extreme possibility is present, bridging the gap between awareness and preparedness is challenging, even on an individual level (Marti et al., 2018) – and especially if the considered event is perceived to have a low probability. This gap may be still harder to bridge in an institutional context, such as within government policy-making, in which short-term thinking can dominate (Nair & Howlett, 2017; Mulligan et al., 2019). In this context, preparedness may be further inhibited by methods explicitly designed to direct limited attentiveness and resources towards high-probability occurrences (Lundgren & Stefánsson, 2020). Any resulting lack of attentiveness to low-probability occurrences is particularly problematic when it comes to pandemics, which have a 'fat-tailed'[1] probability distribution (Taleb, 2020; Cirillo & Taleb, 2020). All moments of such a probability distribution, including the mean and variance, are potentially infinite (Cirillo & Taleb, 2020). This exacerbates such events' uncertainty, particularly in terms of their potential extremity.

This uncertainty is further increased by their 'multiplicative' (Cirillo & Taleb, 2020, p.607) nature, which is the source of their potential extremity. An inadequate understanding of this multiplicative nature, which stems from the exponential spread of an infectious disease, may exacerbate any existing tendency towards 'exponential growth bias' among policy-makers (Wagenaar & Timmers, 1979; Wagenaar & Sagaria, 1975). Because of their exponential spread, such events' frequency and potential extremity may be under-represented by samples based on past occurrence (Goodwin & Wright, 2010). Furthermore, these problems will still affect any subjective probability attributed instead, since that approach to probability depends on the updating of ex-ante established 'priors'. If frequency and potential scale is obscured by fat-tailed probability distributions and not well represented by past occurrences then this will affect such events' subjective perception too, thus increasing the possibility

[1] Cirillo & Taleb (2020) describe a fat-tailed probability distribution as one in which: 'A non-negative continuous random variable X is 'fat-tailed' if its survival function $S(x) = P(X \geq x)$ decays as a power law $x^{-1/\xi}$ the more we move into the tail, that is, for x growing towards the right endpoint of X'.

of being surprised by them (Feduzi & Runde, 2014; Kay & King, 2020). For these reasons, such extreme events may be given insufficient consideration in planning, leading to under-preparedness.

There is a need, then, to enhance their perception among policy-makers in order to stimulate preparedness for them. One approach is to use Extreme Value Theory in planning and policy-making (EVT - Cirillo & Taleb, 2020). However, a problem would still remain in translating the increased need for preparedness into policy action. Neither the nature of fat-tailed distributions, nor EVT, are well understood by policy-makers. Plausibility-based scenario planning may assist by enhancing the perceived probability of rare and extreme events, thus stimulating preparedness for them (Wright & Goodwin, 2009; Goodwin & Wright, 2010). This is achieved through a structured process of causal analysis, which culminates in participants writing narratives describing the unfolding of causal sequences (i.e. the detailed causal mechanisms) by which extreme outcomes might occur (Cairns & Wright, 2018). Psychological experiments show that creating, or even just being presented with, narratives describing the reasons why an uncertain event occurred from a retrospective perspective, or simply the reasons why it *might* occur, may increase subjective-probability judgments of its occurrence (Kuhn & Sniezek, 1996, p.233; Hoch, 1985; Hendrickx et al., 1992; Hendrickx et al. 1989; Levi & Pryor, 1987). This may increase the perceived probability of extreme events such as a pandemic, rendering it more congruent with the increased frequency and potential scale implied by a fat-tailed probability distribution, thus stimulating preparedness for them.

This effect, leading to an increased perceived probability for extreme events, has been suggested (Schoemaker, 1993) to stem from the conjunction fallacy induced by the writing of narratives describing sequences of causes (Tversky & Kahneman, 1983). It was originally deemed a deviation from normative decision-making rationality. However, Schoemaker (1993) subsequently argued that inducing this heuristic can work beneficially to overcome biases associated with myopia and business-as-usual thinking. Essentially, under this view, in plausibility-based scenario planning the conjunction fallacy is used to overcome biases that inhibit preparedness for potentially extreme outcomes (Kuhn & Sniezek, 1996). In this way, plausibility-based scenario planning may improve preparedness for events such as

COVID-19. Moreover, by diminishing overconfidence in the continuance of business-as-usual in their wake, it can aid precautionary decision-making.

3. PLAUSIBILITY-BASED SCENARIO PLANNING AS AN AID TO PRECAUTION

The diminished ability to perceive, or any tendency to outright disregard, the possibility or potential extremity of events like a pandemic may also have serious consequences for the decisions made when faced by one. There are many versions of the precautionary principle (PP) and none is universally-accepted (Sandin, 1999; Stefánsson, 2019). However, that in the SRA glossary has been established based on the consensus of a broad range of experts (Aven & Bouder, 2020). It states that the PP is 'an ethical principle expressing that if the consequences of an activity could be serious and subject to scientific uncertainties, then precautionary measures should be taken, or the activity should not be carried out' (SRA, 2018, p.8). Aven (2011, p.1520) notes a commonality among the many other definitions of the PP to be that it 'should apply when the consequences…could be serious…[and] we do not fully understand what could happen' and that 'there must [therefore] be a *potential for surprises*' (emphasis added). Stirling and Gee (2002) suggest the PP be used when an accurate predictive model is not available, and there is little or no evidence by which to assign probabilities (Boyer-Kassem, 2017). Elsewhere, the irreversibility of a decision is emphasised as a criterion for invoking it (Aldred, 2012).

Plausibility-based scenario planning has theoretical foundations in Potential Surprise Theory (PST - Shackle, 1955, 1961) in which each of these aspects of precaution features prominently: the potential for surprises, seriousness of impact, an absence of evidence by which to assign probabilities, and irreversibility (Derbyshire, 2017). Plausibility-based scenario planning can contribute to precautionary decision-making in the face of extreme events like a pandemic by ensuring the full range of possible outcomes, and thus the full extent of uncertainty, is taken into consideration. In setting out PST, Shackle (1955, 1961) described the reasons that probability – both frequency-based *and* subjective – is unable to deal with the fundamental uncertainty present in much real-world decision-making. In PST, such fundamental uncertainty is present where a decision would destroy and remake anew a current state space of possibilities (thereby destroying the 'priors' that exist on a subjectively-defined version of it), and where the decision may have a high (and negative) impact because of its irreversibility (Feduzi &

Runde, 2014; Derbyshire & Giovannetti, 2017). The PST decision-making approach, set out by Shackle (1955; 1961) as an alternative for use in just such circumstances, has six steps (Derbyshire, 2017, p.80):

1) for a decision under consideration (e.g. the response to a pandemic) imagine a set of rival strategies and their outcomes;

2) for each outcome to each strategy, consider its plausibility (e.g. whether it is perfectly possible, or would be somewhat surprising, or completely implausible etc. under current conditions), resulting in a measure for it on a 'surprise scale';

3) for each outcome to each strategy, imagine its impact (e.g. the gains or losses that might result from it, such as saved or lost lives in a pandemic);

4) for each strategy, identify the single outcome that is most arresting because of the *combination* of its plausibility (as in 2) and its potential *positive* impact (as in 3), and the single outcome that is most arresting because of its plausibility (as in 2) and its potential *negative* impact (as in 3). This results in the creation of two 'focus outcomes', determined formally as the maximisation of a continuous stimulation function (for potential gains and losses) subject to a continuous potential surprise function (for plausibility), for all strategies;

5) consider the respective pairs of focus outcomes by comparing the trade-off between losses and gains (Zappia, 2014, p.1139; Earl & Littleboy, 2014, p.98);

6) select the strategy for which this trade-off is maximised (i.e. potential gains are largest in comparison to potential losses).

To illustrate the type of fundamental uncertainty dealt with by PST, Shackle (1955, p.4) used the example of a sentry who is caught up in a rebellion and who must decide whether to follow the commands of his captain who has treacherously joined the side of the rebels, or to remain loyal (Derbyshire, 2017). The sentry considers that obeying his captain and joining the rebellion could result in two outcomes: the rebellion succeeds and he remains a soldier in the guard, or the rebellion fails, and he is beheaded. On the other hand, if he remains loyal by not joining the rebellion, two alternative scenarios could occur: the rebellion succeeds and he is beheaded, or it fails and he is rewarded handsomely for his loyalty. The soldier, considering these possible scenarios, finds only the last to be an attractive outcome, and opts for that one, and is duly rewarded as the rebellion fails.

Shackle (1955, p.3) discusses how a probabilistic analysis might have led to a very different decision. We here extend Shackle's discussion so that it more explicitly includes subjective probability, as-well-as that which is frequency-based, as Shackle intended (Earl & Littleboy, 2014; Derbyshire, 2017). The sentry may have examined some historical records and found a thousand similar cases, and that in six hundred the rebellion succeeded, under which circumstances those who had remained loyal were beheaded. Similarly, the sentry could have constructed a subjective probability based on prior knowledge of such rebellions, and updated it with the little presently-available evidence related to *this* rebellion, which suggested the rebels' greater strength. On one or other probabilistic basis, the sentry may have made the opposite decision to join with his captain in rebelling.

However, having one's head cut off is a rather final act. If the sentry had chosen to join the rebellion based on his probabilistic analysis, 'just before the axe fell, [he may have had time] to reflect that he would never, in fact, be able to repeat his experiment a thousand times, and thus the guidance given him by actuarial considerations had proven illusory' (Shackle, 1955, p.3). Similarly, just before the axe fell, the sentry may have had time to update his prior again, so that it includes the new information that the rebellion was too weak to succeed in this instance – before then being beheaded. The point of this story is that probability, whether subjective or frequency-based, provides little useful guidance for one-off, 'crucial' (Shackle, 1955, 1961) decisions with major consequences, which change the circumstances in which the decision is made meaning that no future decision can be made in the same circumstances again (Derbyshire, 2017; Basili & Zappia, 2009). A danger with using probability for such decisions is to place the focus on the relative probabilities, rather than on the potential outcomes and their impacts.

When the initial outbreak of COVID-19 occurred in the UK, the UK government firstly attempted to model the 'actuarial considerations' (Shackle, 1955, p.3) instead of immediately invoking the PP by implementing a stringent quarantine or 'lockdown' (Adam, 2020). This represented a failure to understand the decision's crucial nature (i.e., its irreversibility). The decision *not* immediately to implement a strict quarantine, and instead to model the actuarial considerations, changed the circumstances in which it was taken, such that no future decision could ever be taken in the same circumstances again. Essentially, the UK government's decision *not* immediately to lockdown eliminated from the decision space the possibility for containing the outbreak with minimal harm. It treated this decision as the opposite of a crucial and irreversible one: as a reversible one open to experimentation. However, in the case of a pandemic, *not* treating a lockdown decision as crucial is an error with potentially devastating long-term consequences. Delay in implementing a strict quarantine in the presence of exponential viral spread is potentially catastrophic.

The 'crucial' (Shackle, 1955; 1961) nature of such a decision leads to an asymmetry in the payoff from the two alternative options: to implement a strict quarantine or not to implement one. The payoff function would be convex in one instance and concave in the other as in Taleb's (2012) concept of antifragility, for the reasons now described. Based on the discussion in Aven (2020), a type I precautionary error in responding to a pandemic would occur if a strict quarantine is unnecessarily implemented due to the focal virus' failure to spread. However, if this type of precautionary error does indeed occur, implementing an unnecessary quarantine has cost little – just a small amount of lost economic output – and the decision can be easily reversed. Yet, if a strict quarantine is instead proven to have been *necessary*, because the virus does indeed spread, there is an exponentially increasing, positive payoff from the quarantine in terms of curtailing spread, saving life, and protecting the economy. This type 1 precautionary error is therefore representative of Taleb's (2012) convex payoff function and *is* antifragile (Derbyshire & Wright, 2014).

Conversely however, a type II precautionary error (Aven, 2020) would occur where a strict quarantine is *not* implemented because the focal virus is *not* deemed a threat, but is then proven to have been necessary because the virus spreads causing great harm. Here, the gains from the decision *not* to implement a strict quarantine being proven correct are minimal in terms of continued business-as-usual. However, there is an exponentially increasing, negative payoff in terms of loss of life and economic activity should the decision *not* to implement a quarantine be proven erroneous. Furthermore, the decision in this latter case is *not* reversible as it was in relation to the Type I error. A retrospective quarantine *cannot* contain the exponential spread of a virus in the same way as can an early one. Largescale loss of life is therefore all but guaranteed if this precautionary error is made. This precautionary error is therefore representative of Taleb's (2012) concave payoff function and is *not* antifragile (Derbyshire & Wright, 2014).

We also see in this discussion of type I and II precautionary errors the 'focal gains and losses' that feature in PST under 'crucial' (Shackle, 1955; 1961) decision circumstances. Plausibility-based scenario planning, because of its theoretical foundations in PST (Derbyshire, 2017), would place the focus squarely on these focal gains and losses and by doing so would emphasise the avoidance of a type II precautionary error. A type I precautionary error emphasises the costs of erroneously taken precautionary measures, whereas a type II precautionary error emphasises the costs of an erroneous *lack* of precautionary measures (Aven, 2020). While there is no 'scientifically optimal formula' (Aven, 2020, p.1892) for making such a decision, where there is danger of exponentially increasing harm, the payoffs to alternative actions described above clearly favour avoiding a type II precautionary error, as Norman et al. (2020) have emphasised. Plausibility-based scenario planning places the emphasis on avoidance of type II precautionary errors. The process of writing, or even just considering, sequences of causes leading to extreme events can increase acceptance that there is a wide range of possible outcomes from them, including some that are devastating (Kuhn & Sniezek, 1996, p.245). This can reduce complacency when faced by them. Focusing on impact rather than relative probabilities, as in plausibility-based scenario planning, can aid realisation of the need for precaution.

4. PLAUSIBILITY-BASED SCENARIO PLANNING AS A BRAKE ON MODELLING HUBRIS

As recognised in this journal, there is increasing concern within the risk-analysis field that, for many of society's most pressing contemporary challenges, probabilistic models of uncertainty cannot always be confidently determined or agreed (Shortridge & Guikema, 2012). To this we can add that, even if probabilities were estimable and could be agreed given sufficient time, attempting to estimate them under circumstances that may lead to 'ruin', as in a pandemic (Norman et al., 2020), may bring about exactly that: ruin. Upon initial outbreak of a pandemic, even if probabilities could be estimated for the effectiveness of alternative mitigating actions given sufficient time, they cannot be meaningfully estimated in the time available before a decision must be made (Yu et al., 2012). Stating that they *could* be estimated given enough time, and that uncertainty is therefore always amenable to probabilistic estimation, is beside the point. Under such extreme circumstances, the focus should therefore shift from 'actuarial considerations', as Shackle (1955, 1961) called them, to the potential extremity and desirability of alternative outcomes.

This logic is borne out by the UK government's initial response to COVID-19 in March 2020. In a special report in *Nature* on 'modelling the pandemic', Adam (2020) discusses the reasons for the UK government's pivot away from an initial strategy aimed at 'herd immunity' to one of strict quarantine (i.e. 'lockdown'). According to Adam (2020), modelling carried out by Professor Neil Ferguson and colleagues at Imperial College London played a role in this decision. This modelling initially employed an assumption of 15% for the proportion of COVID-19 cases admitted to hospital who would require intensive-care treatment, based on advice from clinicians who had examined data from the original outbreak in China (Adam, 2020, p.318). However, the clinicians subsequently spoke to Italian colleagues following the outbreak's development there, thus discovering that the proportion of patients requiring intensive care was more like 30%. This new assumption, when inputted into the model, changed its implications for the UK's National Health Service in terms of whether it would be overwhelmed, contributing to the UK government's belated pivot to a strict quarantine (Adam, 2020). However, this pivot was not made until after a crucial period of delay, potentially causing greater loss of life than may have otherwise occurred.

If Adam's (2020) account is correct, from one perspective, modelling has played a key role in the improved decision to implement a strict quarantine. This might therefore be considered a successful case of model-based, Bayesian updating. Yet, from another perspective, the uncertainty of the model in question should have meant that the modelling evidence be ignored. The considerable uncertainty inherent in the model is evidenced by the size of the change to the focal parameter related to ICU admissions (15% to 30%). This raises a question as to why a model containing such a high degree of uncertainty was allowed any bearing on decision-making in the first place. One explanation is what

Saltelli et al. (2020) refer to as the ‘hubris’ of modelling, which leads the modellers and those they are advising to think they know more than they really do, and that the full extent of uncertainty has been captured by the model.

Plausibility-based scenario planning can help in this regard too by redirecting focus away from the bounded and epistemic uncertainty associated with what *is* known, as incorporated in modelling, and onto the more fundamental uncertainty associated with what is *not* known (Saltelli et al., 2020, p.484) – or what Shackle (1983) called ‘unknowledge’. It does so by making extremity of outcome and uncertainty integral to the analysis. For example, in the Intuitive Logics variant of plausibility-based scenario planning (Cairns & Wright, 2018) the future is framed by considering the potential extremity of impact of alternative causal sequences, and the extent of perceived uncertainty in relation to their resolved outcomes, such as in terms of lives lost or saved in a pandemic. By considering several such plausibility-based scenarios, a broader uncertainty and range of potential outcomes is taken into consideration than by modelling alone, thus ensuring decision-making is not exclusively based on the bounded uncertainty of modelling.

5. CONCLUSION

The COVID-19 crisis exposed many countries’ high level of under-preparedness for extreme events such as a severe pandemic. Yet, pandemics’ increasing frequency and scale has been highlighted in publications such as the Global Risks Report annually. It is thus tempting and easy to castigate governments for their ineptitude, or perhaps even negligence, in not preparing better. Yet, if the dominant tools and techniques for assessing and considering such extreme events do not reflect such events’ true frequency and potential scale of impact, which are fat-tailed in their distribution, then it is hardly surprising if governments under-prepare for them. While there are better means by which to assess their potential occurrence and scale, such as Extreme Value Theory, few policy-makers understand such approaches or grasp its implications for preparedness.

This brings to the fore a need to increase such extreme events’ perceived possibility and greater realisation of their potentially-devastating scale. Plausibility-based scenario planning is one means by which to do so and thus stimulate greater preparedness for them. The benefits from improved preparedness may be best illustrated by reference to one of the countries least affected by COVID-19. Taiwan may have been better prepared for COVID-19 because of the prominence of such events and the realisation of their potential extremity resulting from the impact on that country of SARS in 2002. This may have rendered stark the need to maintain preparedness in the face of such threats. Other countries, such as the UK, had been little affected by events of this type for many decades. Under such circumstances, plausibility-based scenario planning has a role to play in ensuring that what is 'out of sight' is not also 'out of mind'.

Moreover, because of its theoretical foundations related to Potential Surprise Theory, plausibility-based scenario planning can also play a role in asserting precaution, and thus avoiding a type II precautionary error, in the face of such extreme events. It can also assist in mitigating the modelling hubris that may inhibit precautionary decision-making by ensuring the full range of possible outcomes, and therefore the full extent of uncertainty, is taken into account when making them. Plausibility-based scenario planning can therefore play an important role in the 'type B', 'generic and fundamental' risk science concerned with identifying better ways to present and communicate uncertainties, as discussed recently in this journal.

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