Attributions for ambiguity in a treatment-decision context can create ambiguity aversion or seeking

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Abstract
The phenomenon of ambiguity aversion suggests that people prefer options that offer precisely rather than imprecisely known chances of success. However, past work on people's responses to ambiguity in health treatment contexts found ambiguity seeking rather than aversion. The present work addressed whether such findings reflected a broad tendency for ambiguity seeking in health treatment contexts or whether specific attributions for ambiguity play a substantial role. In three studies, people choose between two treatment options that involved similar underlying probabilities, except that the probabilities for one option involved ambiguity. The attributions offered for the ambiguity played an important role in the results. For example, when the range of probabilities associated with an ambiguous treatment was attributed to the fact that different studies yield different results, participants tended to show ambiguity aversion or indifference. However, when the range was attributed to something that participants could control (e.g., regular application of a cream) or something about which they were overoptimistic (e.g., their immune system function), participants tended to show ambiguity seeking. Health professionals should be mindful of how people will interpret and use information about ambiguity when choosing among treatments.

Keywords
ambiguity, attributions, health decisions

1 INTRODUCTION

Imagine you have a severe skin rash and are faced with choosing one of two possible treatments. Treatment A has a 75% success rate (i.e., it clears the rash in 75 out of 100 people) and Treatment B is said to have a 60%–90% success rate. You might recognize that the implied probability of success is the same for the two options, but would you ultimately avoid or choose Treatment B, whose probability information is somewhat ambiguous? A hesitation to try Treatment B would fall in line with a classic finding in the judgment and decision-making literature known as ambiguity aversion (Ellsberg, 1961). A preference for Treatment B would fit the label ambiguity seeking (Highhouse, 1994). Absent from the above scenario is any attribution or reason for why Treatment B was said to have a range of probabilities. In health-decision contexts, there are a variety of reasons that might be relevant. The present research addressed how different attributions for the ambiguity might influence ambiguity aversion vs. seeking in choices among health treatments.

Daniel Ellsberg (1961) popularized the notion of ambiguity aversion using balls-in-urns scenarios. Take, for example, a scenario in which drawing a red ball yields a prize, and there are two urns to pick from. One urn is known to contain a 50–50 ratio of red to black balls, and the other contains an unknown ratio of red to black balls. Most people prefer to draw from the first, unambiguous urn, suggesting an aversion to ambiguity (Ellsberg, 1961; Yates & Zukowski, 1976). Ambiguity aversion has since been demonstrated with a variety of hypothetical games of chance (e.g., Heath & Tversky, 1991; Moore &
Health behavior and decision making is another domain in which ambiguity aversion has been studied. In this domain, there are many situations in which physicians and risk communicators are unsure what precise number would best reflect crucial probability information. Consequently, ambiguity can be involved in a number of situations in which likelihood information is relevant, such as informing people about contagion risk, site effect risk, diagnosis confidence, or disease rates at rates that apply to average person (Han et al., 2019; Hillen et al., 2017). Studies tend to find that such ambiguity has negative implications—manifesting as increased worry and risk perceptions (Han, 2016; Han et al., 2006; Han et al., 2011; Han, Klein, et al., 2009), decreased willingness to adopt a health-protective behavior such as genetic testing or vaccination (Hoy et al., 2014; Ritov & Baron, 1990), or avoidance of decision making altogether (Han et al., 2011; Kuhn, 1997; Kuhn & Budescu, 1996). However, much of the research on ambiguity in health contexts focuses on presenting participants with ambiguous risk-related information about a diagnosis or a single treatment and measuring cognitive and affective reactions (see Han, 2016; Politi et al., 2007, for reviews). This differs from our approach and our question of how ambiguity (and attributions for it) influence participants’ choices between treatments.

Our paradigm used versions of the skin cream scenario described in the opening of this paper. As in the classic Ellsberg paradigm, respondents needed to choose between two options, which were treatments. Although this specific approach to studying reactions to ambiguity in a health context is rare, it bears resemblance to that of Bier and Connell (1994). In both of their studies, participants were also asked to choose from two treatments differing in whether probabilities were precise or depicted as a range. The ambiguity of those ranges was attributed to different studies having different findings. In both of their studies, participants preferred the ambiguous treatment when the scenario was positively framed. Highhouse (1994) used a somewhat similar paradigm asking people to make choices among pairs of treatment options in which one of the success probabilities was depicted as a range. Like in Bier and Connell (1994), there was a significant tendency toward ambiguity seeking.

The fact that both Highhouse (1994) and Bier and Connell (1994) found ambiguity seeking raises the possibility that treatment decision contexts are generally consistent in promoting ambiguity seeking, rather than aversion. This is one hypothesis that was tested in our work. However, an alternative hypothesis, which plays a larger role in our work, was that the manner in which treatment decisions are influenced by ambiguity will vary substantially as a function of the attributions for the ambiguity (i.e., the reason offered for the ambiguity). We briefly discuss these possibilities before outlining our studies.

2 Why Ambiguity Seeking Might Be Common in Health Decision Contexts

Again, one hypothesis is that treatment decision contexts are generally consistent in promoting ambiguity seeking. We note three interrelated reasons why this is a plausible possibility. First, in a health-treatment context, people’s goals are to get better. This matches the presumed function of the treatment—to make people better. Perhaps this combination creates a general tendency for people to direct attention to treatment options that have the greatest potential upside.

Second, although pessimism about probability information may be influential in many ambiguity-aversion paradigms (Ert & Trautmann, 2014; Highhouse & Hause, 1995), optimism operationalized in various ways—has also been separately identified as relevant to how people respond to ambiguity (Bier & Connell, 1994; Dieckmann et al., 2017; Han et al., 2011; Highhouse, 1994; Pulford, 2009). Perhaps motivated optimism, or a desire to be optimistic, is especially strong for treatment outcomes. As such, the more optimistic side of an ambiguous probability range might get special attention from a decision maker, making ambiguous descriptions of probability more appealing than non-ambiguous ones (for related ideas, see Dieckmann et al., 2017; Lench et al., 2014).

Third, when people believe they have an illness or malady that could get worse, they may be especially likely to favor bold or risky approaches (Lakdawalla et al., 2012). This is related to the notion that people are risk seeking in a loss domain (Kahneman & Tversky, 1979). Being risk seeking and ambiguity seeking are not formally the same, but they are empirically related (Lauriola & Levin, 2001), and there is some intuitive logic to viewing the choice of an ambiguously described treatment as being a risky action.

3 Why Reactions to Ambiguity Might Be Contingent on Attributions

Despite the above reasons for the hypothesis that ambiguity seeking is a common tendency in treatment-decision contexts, there are also reasons for hypothesizing that the manner in which decisions are influenced by ambiguity will vary as a function of the attributions offered for the ambiguity. In various domains, people’s reactions to ambiguity have been shown to be influenced by moderators (see Trautman & van de Kuilen, 2015, for a review). Usually these moderators influence how much ambiguity aversion is observed at a sample level. For example, ambiguity aversion appears to be stronger when options are presented jointly as compared to separately (Fox & Tversky, 1995; Fox & Weber, 2002) and when ambiguity is ascribed to conflict between experts (Benjamin & Budescu, 2018; Cabantous et al., 2011; Han, Reeve, et al., 2009; Smithson et al., 2019).

Here, our interest is specifically on attributions for ambiguity that are both relevant to a health-decision context and might influence reactions to ambiguity. Prior literature on this issue leaves an unclear picture. We now of one directly relevant study, which tested three different attributions for ambiguity in a treatment choice context for leg pain (Curley et al., 1984). Ambiguity was attributed to (1) lack of testing for the new treatment, (2) a vague reference to variability in effectiveness, or (3) the possible inaccuracy of a specialist. The design of the study, however, made it impossible to separate ambiguity
indifference (no sample-wide preference for one treatment over the other) from ambiguity seeking, limiting our ability to compare its overall findings to Bier and Connell (1994) and Highhouse (1994). But, as for ambiguity aversion itself, attributions did not play a significant moderating role. This seems a surprising result worthy of more testing.

An ambiguous range of probabilities associated with a health treatment could be attributed in a variety of ways. In attributions mentioned thus far from previous research (Bier & Connell, 1994; Curley et al., 1984; Highhouse, 1994), the source of the ambiguity was not directly related to the self (i.e., to the respondent or patient). For example, attributing a probability range to the fact that different effectiveness studies have found different success rates for a treatment is impersonal rather than person-specific. However, there are potential attributions about ambiguity for health treatments that are person specific—for example, attributing a probability range to the fact that different medication-adherence levels or different immune-system states yield different success rates for a medication.

Attributions that are personal rather than non-personal might involve dynamics that could shift how people respond to ambiguity. Personal attributions might refer to the control people have in a treatment process or to knowledge an individual has that is relevant to the attribution. Both knowledge and perceived control are known to be relevant to people’s choices under uncertainty (Heath & Tversky, 1991; Keren & Gerritsen, 1999; Klein et al., 2010; Langer, 1975). Consistent with their competence hypothesis, Heath and Tversky (1991) found that people prefer to bet on their own ambiguous judgments rather than precisely defined chance in situations where they feel knowledgeable or competent but prefer to bet on chance when they do not feel competent. Various work on controllability shows that people prefer controllable risks and bets over ones determined purely by chance and are more optimistic about negative events that they perceive as controllable (Goodie, 2003; Harris, 1996; Klein & Kunda, 1994). Consequently, attributions that relate the ambiguity of a treatment’s effectiveness to something about which people have specific knowledge or control might make people less averse to, or even feel sanguine about the ambiguity. In testing our hypothesis that the influence of ambiguity on decisions will vary as a function of the attributions for the ambiguity, some of our studies involved strictly impersonal attributions but others involve attributions in which personal factors (i.e., knowledge and control) are relevant.

4 | OVERVIEW OF THE PRESENT STUDIES

We present three studies that all used the scenario mentioned earlier, in which participants needed to choose between two skin creams for a severe skin rash. The underlying probabilities for the two treatments were always equivalent—even though ranges were used to describe probabilities for one of the treatments. Crucially, different attributions for these ranges were introduced to test how they affected choices (and thereby reactions to ambiguity). The initial study included health-relevant attributions that were not person-specific and instead referred to differences in treatment batches or effectiveness rates from different studies. The results of this study contradicted the hypothesis that ambiguity seeking is a common response for treatment-decision scenarios. Studies 2 and 3 introduced other health-relevant attributions that were person-specific, which yielded evidence that responses to ambiguity vary as a function of the type of attribution.

5 | STUDY 1

Study 1 tested the impact of two impersonal attributions for ambiguity in the context of a health-treatment decision. Participants chose between two treatments, where the probability of success for one of the two treatments was described as a range. For participants in the different-studies group, this ambiguity was attributed to different studies producing different results about that treatment (similar to Bier & Connell, 1994). For participants in the different-batches group, the ambiguity was attributed much differently. We constructed the scenario in this condition to have some of the luck-of-the-draw characteristics that Ellsberg’s ball-in-an-urn scenarios had.

One possible result from these studies would be to find ambiguity seeking in both conditions. This finding, coupled with findings from Bier and Connell (1994) and Highhouse (1994), would suggest that ambiguity seeking is common in health treatment decisions irrespective of different attributions. A key alternative possibility was that the attributions would matter—perhaps finding ambiguity aversion in the different-batches condition designed to have the luck-of-the-draw characteristics of the Ellsberg paradigm.

5.1 | Method

Study 1 was comprised of two separate, essentially identical, studies that were conducted at separate times with two different samples. Given their similarity and that there were no significant differences between the two samples on any of our dependent measures, we have aggregated the data and report the combination as one study.

5.1.1 | Participants and design

A total of 492 participants completed Study 1. Roughly half (42.3%, N = 208) were Amazon Mechanical Turk (Mturk) workers paid a small fee for their participation ($M_{age} = 34.37, SD_{age} = 12.66$; 38.9% male, 57.2% female; 8 did not report gender) while the other half (57.7%, N = 284) were students at a large Midwestern university who completed the study online in exchange for course credit ($M_{age} = 19.18, SD_{age} = 1.35$; 39.1% male, 59.9% female; 3 did not report gender). This sample size gave us 80% power to detect a small-sized effect (specifically, a between-groups difference of $d = .25$, Faul et al., 2007). Participants were randomly assigned to either the
different-studies or different-batches condition. A counterbalancing of treatment order did not produce any interactions with this condition factor and is not discussed further (see Supporting Information).

For all studies, we report all manipulations and all measures in the study. No data exclusions were made (Simmons et al., 2012). Sample-size targets were set prior to data collection.

5.1.2 | Materials and procedure

Participants first completed an instructional attention check (Oppenheimer et al., 2009). Then they were asked to imagine that they had been diagnosed with an unpleasant rash on their arm which needed treatment or would last for months. There were two possible treatments, both creams, applied once per day for 2 weeks. The probability of success with one cream (the unambiguous treatment) was communicated as a single-point estimate. The probability of success with the other cream (the ambiguous treatment) was communicated as a range of estimates. The description of this information and the attributions about ambiguity differed between the two between-subject conditions.

Participants in the different-studies condition were told that one cream was successful in 75% of cases and the other was successful in between 60% and 90% of cases. The reason for the range of possible success rates for the ambiguous cream was described as varying “because different studies produced different results.”

In the different-batches condition, there was a luck-of-the-draw element à la Ellsberg’s balls-in-an-urn scenarios. Participants were told that the success of either treatment depended on whether the active ingredient in a bottle of cream was still active when it was purchased. For the unambiguous cream, 75% of the bottles still contained the active ingredient after being shipped. For the ambiguous cream, between 60% and 90% of the bottles still contained the active ingredient. The reason for the 60%–90% range was “because different batches of the cream can have different proportions of bottles in which the active ingredient remains active.” See Appendix A for the full text of these scenarios.

5.1.3 | Dependent measures

Treatment choice
First, participants indicated which treatment they would choose on a 4-point scale (1—definitely choose Cream A, 2—probably chose Cream A, 3—probably chose Cream B, 4—definitely choose Cream B). They were also asked to explain their choice (these responses are described in the Supporting Information).

Likelihood judgments
Next, verbal likelihood estimates were solicited in two separate judgments. “For Cream A(B), how likely does it seem that the treatment would be successful for you?” (1 = not very likely, 7 = very likely). Although these judgments were made on a numeric, Likert-type scale, for ease of description, we will refer to them as verbal likelihood judgments to distinguish them from the next set of likelihood judgments. Participants were then asked to imagine that they had selected each cream in turn and to estimate the numeric likelihood that the cream would be successful for them. Responses were made on a slider scale that displayed numbers in 5-point increments from 0 to 100%—with text indicating that 0% would mean “certainly fail” and 100% would mean “certainly be successful.”

Additional exploratory measures
On seven-point scales, participants then answered how healthy they generally consider themselves to be, how much control they feel they have over how strong their immune system is, how confident they are that their body generally responds well to treatments and recovers quickly, how much control they feel they have over whether the treatment would be successful for them or not, and how suspicious they were about the claims made for each treatment. Next, participants saw a modified version of the Ellsberg urn paradigm. They were asked to choose an urn to draw from when one contained 50 red and 50 black balls and the other contained between 35 and 65 red balls, with the remainder being black. Participants in the university sample then explained their selection. Finally, participants completed a measure of dispositional optimism (LOT-R; Scheier et al., 1994) as well as demographic questions.

5.2 | Results for study 1

5.2.1 | Treatment choices

Figure 1 shows the (dichotomized) proportions of participants who preferred the ambiguous option (35.7%) over the unambiguous one. As is evident from the figure, there was no general trend toward ambiguity seeking.

For inferential tests, we coded responses from 1 to 4 such that higher values reflected preferences for ambiguity seeking. Preferences for avoidance/seeking did not differ between the two conditions, t (488) = .25, p = .80. The grand mean (M = 2.26, SD = 0.79) was significantly below the 2.5 midpoint, t(489) = −6.70, p < .001, d = .30. In other words, there was a significant tendency toward ambiguity aversion. This tendency toward aversion was significant within both the different-studies condition (M = 2.27, SD = .82), t(247) = −4.40, p < .001, d = .28, and the different-batches condition (M = 2.25, SD = 0.76), t(241) = −5.10, p < .001, d = .33. Analyzing treatment choice using non-parametric tests revealed the same conclusions.

5.2.2 | Likelihood judgments

Results from likelihood estimates were consistent with the overall tendency to select the unambiguous treatment (i.e., the tendency toward ambiguity aversion). Compared to their estimates for the unambiguous treatment, participants’ overall estimates for the
ambiguous treatment were lower on both the verbal scale, $t(481) = 7.43$, $p < .001$, $d = .34$, and numeric scale, $t(477) = 4.80$, $p < .001$, $d = .22$. See Figure 2 for the pattern of means, and the Supporting Information for the overall means. There were some unexpected differences in likelihood judgments between the conditions. However, given the lack of an interpretable pattern, we are cautious of over-interpreting them.

Unsurprisingly, treatment choices were correlated with likelihood judgments (see Table 1). Participants who were more likely to select the ambiguous treatment also thought the ambiguous treatment was more likely to work (or the unambiguous treatment less likely to work).

5.2.3 Additional results

Analysis of the exploratory measures did not reveal findings of note in regard to our manipulation or treatment choice. In the modified
Ellsberg urn paradigm, participants displayed strong ambiguity aversion, only 17.8% of the sample selected the ambiguous urn, \( \chi^2(1) = 200.52, p < .001, w = .64 \). These decisions were not significantly correlated with treatment choice (on the 4-point scale) in the skin rash scenario in either condition (point biserial rs < .11; ps > .07).

### 5.3 Discussion for study 1

Ambiguity aversion was more common than seeking, and this was true within both the different-studies and different-batches conditions. This suggests that a treatment-decision context alone is not enough to consistently trigger ambiguity seeking. The ambiguity aversion in the different-studies condition in particular is noteworthy since this utilized a real-world attribution for ambiguity that has produced ambiguity seeking previously (Bier & Connell, 1994). However, this does not mean that people will never show ambiguity seeking in a treatment decision context. Even though these two attributions did not create ambiguity seeking, we reasoned that there may be others that do.

### 6 STUDY 2

Given the consistent ambiguity aversion in Study 1, we wanted to know whether there were other attributions for ambiguity that would still be relevant to a treatment-decision context, but that might produce ambiguity seeking rather than aversion. So, in Study 2, we replaced the different-studies condition with another ecologically plausible attribution for the ambiguity—that the range of success rates was due to the person's overall health-status. Otherwise, the study method was the same as in Study 1.

We thought this health-status attribution might be more likely to produce ambiguity seeking for two related reasons. Both reasons are related to the fact that the attribution references the self (i.e., a characteristic of the person). First, participants might have positive reactions (justifiably or not) to their health status, giving them “grounds” to assume the optimistic part of the range might apply to them. Second, because it attributes the ambiguity to something personal that participants might have some control over, or knowledge of, participants may be more willing to try to ambiguous treatment. Previous research has found that people are more willing to display ambiguity seeking in situations where they feel competent and in control (Heath & Tversky, 1991; Howell, 1971; Klein et al., 2010). Given these conceptual connections, we were also particularly interested in how ambiguity preferences in the health-status condition would relate to some of the additional measures asked at the end of the study. Namely, for that condition, we suspected that participants' beliefs about themselves (their perceived health, perceived control, and confidence) might predict whether the ambiguous treatment would be appealing to them.

### 6.1 Method

Two hundred and seventy-one students from a large Midwestern university participated in Study 2 online (M_{age} = 18.83, SD_{age} = 1.43; 24.7% male, 73.4% female, 5 did not report gender). This sample size gave us 80% power to detect a small-to-medium-sized effect (specifically, a between-groups difference of \( d = .34 \)). Participants were randomly assigned to either the health-status or different-batches condition.5

Participants read the same information about the skin rash and the possible treatments as in Study 1. The different-batches condition attributed the ambiguity in the exact same manner as before. The health-status condition indicated that the ambiguous cream was successful in between 60% and 90% of cases “depending on the overall health of the person.” All dependent measures remained the same.

### 6.2 Results

#### 6.2.1 Treatment choice

Figure 3 depicts the dichotomized rates of preferring the ambiguous treatments, whereas the following analyses are for the full four-point scale (again coded so that high values favor ambiguity seeking). Unlike in Study 1, preferences differed between conditions, \( t(269) = 2.39, p = .017, d = .29 \). Participants in the different-batches condition displayed ambiguity aversion with a mean that was significantly below the midpoint (\( M = 2.36, SD = 0.68 \)); \( t(143) = -2.47, p = .015, d = .21 \). Responses from participants in the health-status condition did not differ from the midpoint, (\( M = 2.57, SD = 0.74 \)), \( t(126) = 1.02, p = .311 \). Analyzing treatment choice using non-parametric tests revealed the same conclusions.

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**Note:** CI = confidence interval. Correlations represent Pearson r correlations conducted with the four-point treatment choice scale.

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Different studies</th>
<th>95% CI</th>
<th>Different batches</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unambiguous verbal</td>
<td>- .30**</td>
<td>[-.41, -.18]</td>
<td>-.39**</td>
<td>[-.49, -.28]</td>
</tr>
<tr>
<td>Ambiguous verbal</td>
<td>.50**</td>
<td>[.40, .59]</td>
<td>.51**</td>
<td>[.41, .60]</td>
</tr>
<tr>
<td>Unambiguous numeric</td>
<td>-.15*</td>
<td>[-.27, -.02]</td>
<td>-.13</td>
<td>[-.25, .00]</td>
</tr>
<tr>
<td>Ambiguous numeric</td>
<td>.46**</td>
<td>[.35, .55]</td>
<td>.36**</td>
<td>[.24, .46]</td>
</tr>
</tbody>
</table>

\*p < .05. **p < .01.
6.2.2 | Likelihood judgments

As in Study 1, participants’ likelihood estimates were higher (albeit only slightly) for the unambiguous treatment than for the ambiguous treatment; this was true on both the verbal, \( t(266) = 2.22, p = .027, d = .14 \), and numeric scale, \( t(267) = 2.33, p = .021, d = .14 \) (see Figure 4 for the pattern of means, and the online Supporting Information for overall means). Unexpectedly, participants gave higher overall likelihood judgments in the health-status condition than in the different-batches condition (\( p < .001 \)) and even for the unambiguous treatment (\( p < .001 \)). This finding does not seem especially relevant to our primary research question, so further discussion of it was reserved for the Supporting Information.

Once again, likelihood judgments were significantly correlated with treatment choice across both conditions. The pattern of correlations was similar to those found in Study 1 (see Table 1), but exact numbers are provided in Supporting Information.

6.2.3 | Additional measures

Recall that for the health-status condition in Study 2, we were particularly interested in correlations between ambiguity preferences (measured by choices) and participants’ beliefs about themselves. Those correlations are displayed in Table 2. Treatment choice in the health-status condition was significantly correlated with perceived health, confidence about responding well to treatments, and perceived control over whether this treatment will be successful. In other words, people with high views of themselves on these characteristics preferred the ambiguous treatment. The same pattern was not evident in the different-batches condition.
Correlations between treatment choice and additional variables in Study 2

In Study 2 we identified a self-focused attribution for ambiguity that increased interest in the ambiguous treatment—at least in comparison to a different-batches condition. With Study 3 we explored three different self-focused attributions for ambiguity—in an application-regularity condition, immune-system condition, and genetic-factors condition. By including three self-focused attributions—all of which have applied relevance to a treatment context—we aimed to learn more about what elements of an attribution about ambiguity to tend to trigger ambiguity seeking. We also included the different-studies condition from Study 1 as a non-self-relevant point of comparison.

6.3 | Discussion

Finally, we wanted to test whether any effects we detected were applicable regardless of whether the probabilities levels were generally high (centered around 75% as in Studies 1–2) or generally low (centered around 25%). Assuming this does not affect responses, this would support one type of generalization of the effects examined here.

7 | STUDY 3

In Study 2 we identified a self-focused attribution for ambiguity that increased interest in the ambiguous treatment—at least in comparison to a different-batches condition. With Study 3 we explored three different self-focused attributions for ambiguity—in an application-regularity condition, immune-system condition, and genetic-factors condition. By including three self-focused attributions—all of which have applied relevance to a treatment context—we aimed to learn more about what elements of an attribution about ambiguity to tend to trigger ambiguity seeking. We also included the different-studies condition from Study 1 as a non-self-relevant point of comparison.

Table 2: Correlations between treatment choice and additional variables in Study 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Health-status condition</th>
<th>95% CI</th>
<th>Different-batches condition</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived health</td>
<td>.43**</td>
<td>[.28, .57]</td>
<td>(-.03)</td>
<td>([-20, .13])</td>
</tr>
<tr>
<td>Confidence</td>
<td>.37**</td>
<td>[.21, .51]</td>
<td>.07</td>
<td>([-10, .23])</td>
</tr>
<tr>
<td>Perceived control over success</td>
<td>.27**</td>
<td>[.10, .43]</td>
<td>.20*</td>
<td>([.03, .35])</td>
</tr>
<tr>
<td>Perceived control over immune strength</td>
<td>.13</td>
<td>([-05, .30])</td>
<td>(-.13)</td>
<td>([-29, .04])</td>
</tr>
<tr>
<td>Optimism (as measured by LOT-R)</td>
<td>.07</td>
<td>([-11, .24])</td>
<td>(-.07)</td>
<td>([-23, .10])</td>
</tr>
<tr>
<td>Choice in Ellsberg urn scenario</td>
<td>(-.03)</td>
<td>([-26, 20])</td>
<td>.16</td>
<td>([-01, .32])</td>
</tr>
</tbody>
</table>

Note: CI = confidence interval. Correlations represent Pearson r correlations conducted with the four-point treatment choice scale. Point biserial correlations were conducted to examine choice in the Ellsberg urn scenario in relation to the four-point treatment choice scale. *p < .05. **p < .01.

Again, participants’ reactions to our modified version of the Ellsberg urn paradigm were strongly ambiguity averse, with only 14.7% of the sample selecting the ambiguous urn \(\chi^2(1) = 132.87, p < .001, w = .71\). As in the previous studies, there was no correlation between treatment choice and choice in the Ellsberg urn scenario in either condition (see Table 2).

6.3 | Discussion

These results support the idea that whether the ambiguity surrounding a treatment is attributed to something external to the self (like which shipment you happen to receive) or internal to the self (like how healthy you are) alters interest in an ambiguous treatment. More specifically, there was an increase in interest in the ambiguous treatment when the attribution was self-relevant. The correlations we observed in this condition between treatment choice and the secondary measures (i.e., perceived health, perceived control, and confidence that they respond well to treatment) suggest that participants integrated their personal situation into the scenario in order to select a treatment. To the extent that people—at an individual or group level—are highly confident or optimistic about these personal characteristics, the present results suggest that they might show increased interest in an ambiguous option when the attribution for ambiguity references those characteristics.

7.1 | Method

7.1.1 | Participants and design

Two hundred and forty-two participants were recruited online via Amazon’s MTurk and paid a small fee for their participation \((M_{age} = 27.69, SD_{age} = 10.30; 65.3\% \text{ male}, 31.4\% \text{ female}, 8 \text{ did not report gender})\). This sample size gave us 80% power to detect a small-to-medium-sized effect between groups \((\eta^2 = .04)\). Participants were randomly assigned to a condition in a 4 (ambiguity attribution: application-regularity, immune system, genetic factors, different studies) by 2 (success rate: low, high) between-subjects design.

7.1.2 | Procedure and measures

The procedure of Study 3 was very similar to the previous studies. After completing the instructional attention check,\(^6\) participants read about the same skin rash and two possible treatments. The attribution for the ambiguous range was manipulated. The application-regularity condition described the ambiguous treatment as varying due to how regularly a person applies the cream (with those who apply it more regularly having a higher chance of success). The immune-system condition attributed the ambiguity to the strength of the person’s immune system (with those with stronger immune systems having a higher chance of success). The genetic-factors condition attributed the range of success rates to a person’s genetic makeup (with certain gene combinations having a higher chance of success than other combinations). Finally, the different-studies condition indicated that different studies had found different results, as in Study 1.
The overall rate of success was also manipulated, although the midpoint of the ambiguous treatment was always equal to the point estimate of the unambiguous treatment. In the “high success rate” condition Cream A was described as working in 75% of cases and Cream B, between 60%–90% of cases, replicating the previous studies. In the “low success rate” condition, Cream A was described as working in 25% of cases and Cream B, between 10%–40% of cases.

Order was not counterbalanced; Cream A was always the unambiguous treatment and Cream B was always the ambiguous treatment.

After reading about the treatments, participants completed the same treatment-choice and likelihood judgment questions as before. They also indicated for each cream how many people out of 100 they thought the cream would be successful for. Finally, participants completed individual difference measures of regulatory focus (Higgins et al., 2001) and numeracy (Weller et al., 2013) as well as demographic questions. Regulatory focus describes whether a person primarily operates with a promotion focus on achieving hopes and accomplishments or a prevention focus on safety and responsibility, which we thought may be relevant to their attitude toward ambiguity (Higgins, 1997). They did not complete the additional measures from the previous studies.

7.2 | Results

7.2.1 | Treatment choice

Figure 5 depicts the dichotomized rates of preferring the ambiguous treatments across the four conditions, whereas the following analyses are for the four-point scale (again coded so that high values favor ambiguity seeking). Critical, attributions mattered, and some produced ambiguity seeking. More specifically, the main effect of attribution was significant, F(3, 234) = 19.63, p < .001, ηp² = .20. The means for the application-regularity (M = 3.46, SD = 0.73) and immune system (M = 2.82, SD = 0.85) revealed significant ambiguity seeking (ps < .01), whereas the means for the genetic-factors (M = 2.40, SD = 0.94) and different studies (M = 2.50, SD = 0.76) conditions were not significantly different from the scale midpoint (ps > .41). These findings were not significantly qualified by an Attribution x Success-Rate interaction, F(3, 234) = 0.58, p = .629, ηp² = .007. Nor did the success-rate factor have a significant main effect on choices, F(1, 234) = 0.44, p = .507, ηp² = .002. Analyzing treatment choice using non-parametric tests revealed the same conclusions.

7.2.2 | Likelihood judgments

Preliminary analyses on likelihood judgments revealed that, as one would expect, estimates on both verbal and numeric scales were much higher in the high-success rate condition than in the low-success rate condition (ps < .001). This was also true for the numeric estimates of how many of 100 people would have success (p < .001). To simplify the analyses, we created difference scores for each of these three sets of likelihood judgments (estimate for the ambiguous treatment minus estimate for the unambiguous treatment). For these difference scores, higher numbers reflect more optimism about the ambiguous treatment (over the unambiguous one). The discussion below focuses on these difference scores; information about original estimates appears in Supporting Information.

For questions about the self’s chances of success, the grand mean of the difference scores were significantly greater than zero for both estimates made on the verbal scale (M = 0.45, SD = 1.46), t(240) = 4.82, p < .001, and numeric scale (M = 4.63, SD = 17.18), t(238) = 4.17, p < .001. In other words, people were more optimistic about their success with the ambiguous treatment than with the unambiguous one. This pattern did not hold for difference scores of people’s estimates about 100 other people (M = 0.51, SD = 12.11), t(238) = 0.65, p = .515. This suggests people largely recognized the objective equivalence of the probability information associated with the two treatments.

![FIGURE 5](image-url) Percent of participants who selected the ambiguous treatment in Study 3. Note. abc Bars without a common letter are statistically different (p < .05). Asterisks indicate significant differences from 50%. ** p < .01
Each set of difference scores were separately analyzed in an Attribution x Success Rate ANOVA. Success rate was not involved in any significant effects (ps > .20). More importantly, attribution had main effects on the difference scores from people’s verbal estimates about the self, F(3, 233) = 15.85, p < .001, η² = .17, and numeric estimates about the self, F(3, 231) = 9.16, p < .001, η² = .11. The attribution main effect was not quite significant in the analysis of difference scores from people’s frequency estimates about 100 other people, F(3, 231) = 2.24, p = .085, η² = .03. Figure 6 shows how these three difference scores varied across the attribution conditions. As is evident from that pattern, people were relatively optimistic about what the ambiguous (vs. unambiguous) treatment could do for them in the application-regularity and immune-system conditions. This was not true for the genetic-factors or different-studies conditions.

The differential optimism expressed about the treatments was predictive of treatment choices. On a sample-wide basis, the correlations between difference scores and treatment choices were r(239) = .70, p < .001; r(237) = .63, p < .001; and r(237) = .43, p < .001, in analyses involving the verbal-self estimates, numeric-self estimates, and numeric-other estimates, respectively. Finally, neither regulatory focus nor numeracy significantly predicted treatment choices or likelihood difference scores (all rs < .12, ps > .06).

### 7.3 Discussion

In this study, people’s preferences for or against ambiguity varied as a function of the attributions for ambiguity. Telling participants that the ambiguous range could be attributed to how regularly they apply the cream or how strong their immune system is increased interest in the ambiguous treatment. In both of these conditions, the ambiguity of the treatment-success rate was attributed to self-relevant factors. This is in contrast to the different-studies condition, where the attribution focused on factors external to the self. However, in our third self-relevant condition—the genetic-factors condition—there was no significant tendency for participants to be ambiguity seeking. This indicates that attributing ambiguity to a self-relevant process is not necessarily enough to push people toward ambiguity seeking overall. Only some self-relevant attributions will have this type of effect. In the application-regularity and immune-system conditions, the self-relevant elements involved in the ambiguity attributions were either controllable (a person can plan to follow all application instructions) or at least could be estimated (the effectiveness of one’s immune system). This is in contrast to the genetic-factors condition, where the crucial element is something participants have no control over and realistically, no way of knowing.

In a follow-up to Study 3, we conducted a study (N = 63) in which one of the conditions was a direct replication of the immune-system condition, except that we included a set of additional measures aimed at providing more insight to why people showed ambiguity seeking. As in Study 3, there was significant ambiguity seeking, with 76.2% of the participants selecting the ambiguous treatment (p < .001). It is perhaps understandable that most people in an immune-system condition would prefer the ambiguous treatment, if most people consider themselves healthy and have a positive view of the strength of their immune system. Indeed, when participants in the replication were asked to rate the strength of their immune system (1 = very weak, 7 = very strong), the mean response was high (M = 5.40, SD = 1.22). Furthermore, these ratings were predictive of their treatment preferences, r(63) = .73, p < .001. That is, the stronger people perceived their immune system, the more they favored the ambiguous treatment. But, were perceptions of immune strength too...
high to be realistic? We also asked participants to rate how strong they thought their immune system was compared to the average person of their age and gender, from much weaker (coded at −3) to much stronger (coded as +3). On this scale, the mean response should, arguably, be at approximately the scale midpoint if people are unbiased (Chambers & Windschitl, 2004; Shepperd et al., 2013). However, the mean response was significantly above 0 (M = 1.06, SD = 1.42), t(62) = 5.93, p < .0001, d = .75. A significant majority of participants (68.3%) gave a response above the midpoint (p < .001). This suggests that an upward bias exists in people’s estimates of their immune system condition—much stronger (coded as +3) than the midpoint (p < .001). This suggests that an upward bias exists in people’s estimates of their immune system condition.

As with the absolute ratings, these comparative ratings also produced ambiguity when making health-treatment decisions. In Study 1, participants were—on the sample level—ambiguity averse regardless of whether the ambiguity was attributed to an impersonal, luck-of-the-draw issue (involving shipment batches) or to a differing-studies issue (involving different studies finding different success rates for a treatment). This indicates that a treatment-decision context alone is not enough to prompt ambiguity seeking. Study 2 found significantly elevated interest in the ambiguous treatment when the ambiguity was attributed to the health status of the person taking the treatment as compared to when ambiguity was tied to an impersonal, luck-of-the-draw issue. This was initial evidence that the specific attribution for ambiguity can influence how people respond to that ambiguity. Study 3 examined four different attributions, three of which were tied to personal characteristics. Not all attributions to personal characteristics produced ambiguity seeking. Participants tended to display ambiguity seeking when the ambiguity was attributed to something they could control (i.e., how regularly the treatment was applied) or something they could reasonably know and were particularly overoptimistic about (i.e., how strong their immune system was). Neither ambiguity seeking nor aversion dominated when ambiguity was attributed to genetic factors, despite this being a person factor. This finding also applied to the only condition using a non-personal attribution (the differing-studies attribution). Finally, a follow-up to Study 3 shed some light on why participants displayed ambiguity seeking in the immune system condition—as they tend to have optimistic views of the strength of their immune systems.

8.1 | Ambiguity seeking is not a broad tendency in choices between treatments

Few studies have examined the role of ambiguity in choices between health treatments. One that did was Bier and Connell’s (1994) studies exploring treatment preference when ambiguity surrounded the likelihood of side effects or treatment effectiveness. Both of their studies attributed the ambiguity to the results of different studies, and both found ambiguity aversion. As discussed in the Introduction, there were three interrelated reasons to entertain the possibility that this ambiguity seeking is a common feature within treatment-choice contexts. First, perhaps the match between a person’s goal of getting better and their knowledge that treatments were design for the purpose of fixing their malady would somehow direct their attention to treatment options that have the greatest upside. Second, optimism is an often-lauded goal in health contexts (e.g., Scheier & Carver, 1992) and previous research has shown a link between optimism and ambiguity seeking (Bier & Connell, 1994; Han et al., 2011; Highhouse, 1994; Pulford, 2009). Finally, given that people engage in greater risk-taking behavior in loss domains (Kahneman & Tversky, 1979), it seemed possible that when faced with a health problem, people might prefer riskier or more ambiguous options.

Despite the plausibility of the idea that treatment contexts might generally promote ambiguity seeking, our results do not support this. Our set of studies included several conditions in which ambiguity seeking was not detected in a treatment-decision context. We found ambiguity aversion or indifference when ambiguity was attributed to a luck-of-the-draw issue, the results of different studies, or genetic factors.

The fact that we found ambiguity aversion (Study 1) or ambivalence (Study 3) when the ambiguity was attributed to the results of different studies may seem surprising given that Bier and Connell (1994) found ambiguity seeking using the same attribution. However, Bier and Connell’s (1994) studies differed from ours in several key ways. First, their two possible treatments varied not only in the presence/absence of ambiguity, but also on other dimensions like the type of side effects they caused. Bier and Connell (1994) suspected that this multi-attribute nature of their scenarios may have “diminished the salience of the ambiguity” (p. 179) and caused participants to use different decision strategies. By contrast, differences in ambiguity was the predominant feature in our scenario (much like in the original Ellsberg urn paradigm; Ellsberg, 1961), perhaps producing the ambiguity aversion we found. Second, the size of the ambiguous range Bier and Connell (1994) used was smaller (±3% or ±5%) than the range we employed (±15%). Previous research in the financial domain on how people react to company earnings estimates has shown that decision makers often prefer narrower ranges to wider ranges or even point estimates because they are more likely to accurately reflect the possible outcome while still being informative (Du et al., 2011; Du & Budescu, 2005). Perhaps participants in Bier and Connell’s (1994) studies were drawn to the narrower range in a way that they were not in our studies, given the wider range we employed. Third, although both their studies and the present studies used health treatment scenarios, there are likely other unknown factors that differed between our studies and theirs that could explain the discrepancy (e.g., the diseases described).

8.2 | Attributions that led to ambiguity seeking

How the ambiguity was attributed proved to be an important factor in how participants responded to the ambiguous treatment option.
Participants favored ambiguity seeking when the ambiguity was attributed to how regularly the treatment was applied or how strong a person’s immune system was (Study 3 and its follow-up). Unlike the attributions in some conditions in which ambiguity seeking was not observed (those referring to different studies or different batches of creams), these attributions point to self-relevant factors, rather than external factors. However, self-relevance alone does not seem to be enough to produce ambiguity seeking, given that the genetic-factors condition from Study 3 did not produce significant ambiguity seeking.

The attributions that did promote elevated ambiguity seeking have at least two things in common. First, the attributions pointed to characteristics that people could feel competence about or at least think as though they could meaningfully estimate. People presumably feel like they can access their health, immune system, and ability to follow treatment instructions, but they cannot know whether they have the genes that would make a treatment work for them. This may be important because previous research has demonstrated that people are more likely to be ambiguity seeking in a domain where they feel competent (Heath & Tversky, 1991; Howell, 1971; Klein et al., 2010). A second, related characteristic of attributions that promoted elevated ambiguity seeking was that the key factors might have been seen by participants as something they could control. People may feel like they have some control over their general health, ability to apply the treatment, or the strength of their immune system (regardless of whether they are actually able to control these things). This controllability feature might be important given prior research showing that people prefer controllable risks and bets to ones determined purely by chance and are more optimistic about events that they perceive as controllable (Goodie, 2003; Harris, 1996; Klein & Kunda, 1994; Langer, 1975).

Parsing the relative influence of perceived competence and control in our findings would be difficult, given their interrelatedness. We suspect interrelated factors like these caused people to make optimistic or self-generous assumptions when they encountered ambiguity attributions that referred to current health status, immune system, and ability to follow treatment instructions. That is, participants may have taken liberties to assume very positive views of the self (e.g., regarding applying the treatment perfectly or estimating the state of their immune system). Research suggest that people routinely exhibit planning fallacies and optimistic biases (for a review, see Windschitl & Stuart, 2015), including within health domains (e.g., Alicke et al., 1995; Buehler et al., 1994; Dunning et al., 2004; Miller et al., 2019; Sultan et al., 2002; Weinstein, 1987).

Additional findings from within our studies lend support to the notion that participants made self-generous assumptions that influenced their approach to ambiguity. In the follow-up to Study 3, participants exhibited an above-average effect when asked about their immune system. A significant majority of the sample reported that their immune system was stronger than the average person of their same age and gender. Furthermore, those who perceived their immune system as stronger were more likely to select the ambiguous treatment. Study 2 revealed similar correlational results. Selecting the ambiguous treatment was associated with better perceived health, increased perceived control, and greater confidence that their body responds well to treatment.

Findings from likelihood judgments in Study 3 are also instructive. Recall that participants indicated how likely it seemed that each treatment would be successful for themselves on verbal and numeric scales. They also estimated the number of people out of 100 for whom the treatment would be successful. For the estimate about 100 other people, participants tended to give similar estimates of how many people would be helped by the ambiguous and unambiguous treatments. However, for likelihood estimates about the self, people were relatively optimistic about what the ambiguous (vs. unambiguous) treatment could do for them in the application-regularity and immune-system conditions.

### 8.3 Limitations, future directions, and conclusions

More research on the role of ambiguity in applied health contexts needs to be done to fully understand how ambiguity affects health decisions (Han, 2016; Han et al., 2019). Our studies represent a step in this direction. With the exception of the (somewhat artificial) different-batches condition, all of the attributions we used represented real, plausible explanations for ambiguity in a health treatment context. We have provided initial evidence that the attribution of the ambiguity matters in this context, but more work is needed on the role of control or competence in these attributions, perhaps with more direct manipulation of these elements. It would also be instructive to explore individual differences in how people respond to ambiguity attributions, given that there is already some work on individual tolerance for uncertainty in health domains (e.g., Geller et al., 1990; Gerrity et al., 1990; Han, Reeve, et al., 2009).

Our studies involved both undergraduates and MTurk participants, and results were similar across samples when compared directly (i.e., in Study 1). Nevertheless, future research should further explore generalizability by using samples that include groups of older adults or sick patients. Not all results would necessarily be expected to be the same as in the present studies. For example, participants from an elderly or sick sample might be less likely to have optimistic views of their immune system, which might affect how they respond to ambiguity attributed to variations in immune-system health.

A related issue worth considering is whether the ambiguity seeking behavior we found can be considered a bias or not. Although we provide evidence that participants were over-optimistic regarding the state of their immune system, it is possible that given the young and relatively healthy demographics of our sample, the ambiguous treatment option could be considered the sensible choice for these participants. This does not change the conclusions of our studies but has potential implications for how medical professionals might approach presenting ambiguity to their patients.

The scope of our measures and materials was, by necessity, somewhat narrow. We intentionally chose to operationalize treatment choice on a scale with no neutral or middle option to reflect the
choice a person in the real world would face (i.e., you must choose one treatment or the other). However, we acknowledge that an indifferent or neutral response may have been popular among participants, which could have changed our results. Additionally, we were most interested in how ambiguity affected treatment choice—however, other work has shown that ambiguity can affect a variety of other variables such as risk perceptions or willingness to adopt health-protective behaviors (Han et al., 2011; Ritov & Baron, 1990). It would be instructive to explore how attribution for ambiguity affects these other metrics of ambiguity aversion. We also used the same health context (a skin rash) in all of our studies. While this control was important to isolate the effects of the ambiguity attribution, further research should investigate whether the disease (or certain characteristics or elements of a disease, such as end-of-life scenarios) might moderate the effects we found here.

Additionally, our participants were always presented with one treatment described with a precise probability of success and one treatment described with a range of success rates. This was done to programmatically focus on how responses to ambiguity shift across attributions. A relevant issue that we did not explore is how varying the widths of the ranges might interact with some of our findings. The width that we used for the range was always ±15%. People’s reactions to a range might reflect the congruence principle, which suggests that people prefer that the level of imprecision in a forecast matches the level of underlying uncertainty about an event (Du et al., 2011; Du & Budescu, 2005). This is balanced with wanting the forecast to be precise enough to be informative. It is possible that people’s conclusions about what level of imprecision (range width) is congruous would depend on the attribution. A range of ±15% might be off-putting in the context of an attribution stating that different studies had different results, but the same range of ±15% might seem more acceptable for other attributions. We doubt these interactions would explain our full pattern of results (e.g., it is unclear why congruity conclusions would be substantially different for a genetics versus immune-system attribution), but it seems worthwhile to explore the role of congruity in how people respond to ambiguity in a health treatment domain.

Clearly, there is a myriad of avenues for future research stemming from the core findings in this paper. Notwithstanding the need for more research, the present studies highlight that, in treatment contexts, systematic or biased reactions to ambiguity cannot be well understood without attention to the attributes that are offered for the ambiguity or that are otherwise generated by patients. Health care providers should be mindful that patients may react to ambiguity in different ways tied to interpretations that might or might not be appropriate under specific circumstances.

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ENDNOTES

1 Some researchers (e.g., Budescu et al., 1988) have noted that Ellsberg’s terms “unambiguous” and “ambiguous” are misnomers and think that the manipulation conveys vagueness or imprecision rather than ambiguity. We recognize this issue, but have chosen to use Ellsberg’s original terminology to be consistent with much of the research surrounding this topic.

2 We use the term “ambiguity seeking” from a situational perspective to describe a tendency for participants to select or prefer an ambiguous option over an unambiguous option, not necessarily to indicate that participants are seeking uncertainty in a psychological sense.

3 A sentence in the midst of an instruction paragraph said to skip the next question. The intent of this check was to detect participants who were not carefully reading and following all instructions. In the MTurk sample, 28.4% failed the check. Excluding these participants does not change the results, so the full sample is reported. In the undergraduate sample, participants who failed the check (72.2%) received a warning and a reminder to read instructions carefully thereafter. We did not use this as an exclusion criterion because they received the reminder in this study. Oppenheimer et al. (2009) demonstrated that this reminder provides some assurance that they may have paid closer attention to the scenario and instructions after that, reducing noise in the data.

4 Verbal likelihood judgments for the ambiguous cream were (marginally) higher in the different-studies condition (M = 4.61, SD = 1.16) than in the different-batches condition (M = 4.40, SD = 1.20), t(483) = 1.94, p = .053, d = .18. A similar effect emerged for numeric likelihood judgments, but for the unambiguous cream—with high estimates in the different-studies condition (M = 72.95, SD = 13.50) than the different-batches condition (M = 68.81, SD = 17.35), t(450.83) = 2.92, p = .004, d = .27.

5 As in Study 1, those who incorrectly responded to the instructional attention check (52%) received a warning to attend to all further instructions carefully. The full sample is reported.

6 14% of participants failed this check. These participants did not receive the warning to read all further instructions carefully. Excluding these participants does not change the results, so the full sample is reported.

7 Repeated measures analyses of the raw variables (not difference scores) revealed the same conclusions as those using the difference scores.

8 This follow-up to Study 3 included two conditions in which a statement that suggested that the application of the two treatments was easy or hard. Because this easy-versus-hard information wasn’t about only the ambiguous treatment, these two conditions aren’t specifically about attributes for ambiguity, thus are largely irrelevant to the paper. For brevity, we do not discuss these conditions further (but see Supporting Information).

REFERENCES


Imagine you have been diagnosed with a skin infection on your right arm that is causing an itchy and unpleasant rash. Without treatment, the infection will likely last for months.

Both medications are creams that are applied once per day for 2 weeks. If a cream is successful, it will heal the infection within 2 weeks. Otherwise, the infection will last for a few months. Various studies have been done to determine the rates of success for the two creams (Cream “A” and “B”).

**APPENDIX A.**

**Study 1 full scenario**

You have been diagnosed with a skin infection on your right arm that is causing an itchy and unpleasant rash. Without treatment, the infection will likely last for months.

Your doctor tells you that there are two types of medication available for treating this type of infection and that you have to pick which medication to try. These medications do not always work. You cannot try one medication first and then try the other, as this could cause complications. You have to pick one of them.

Click the arrow in the bottom right hand corner of the screen to read about the treatments.

**A.1 | Different studies condition**

Both medications are creams that are applied once per day for 2 weeks. If a cream is successful, it will heal the infection within 2 weeks. Otherwise, the infection will last for a few months. Various studies have been done to determine the rates of success for the two creams (Cream “A” and “B”).
Studies show that **Cream A** is successful in about 75% of cases. Studies show that **Cream B** is successful in between 60% and 90% of cases. These rates vary because different studies produced different results.

### A.2 Different batches condition

Both medications are creams that are applied once per day for 2 weeks. Within a given shipment of creams, not every bottle of cream is effective. The creams rely on an active ingredient that can become inactive and ineffective soon after a given bottle of cream is sealed. If the active ingredient is still active when the bottle is purchased, it does a good job of healing the infection after 2 weeks of application. However, if it is inactive, the infection will not clear after 2 weeks and could last for a few months.

Independent studies show that in about 75% of the bottles that contain **Cream A**, the active ingredient is still active after being shipped.

Independent studies show that in between 60 and 90% of the bottles that contain **Cream B**, the active ingredient is still active after being shipped. This rate varies because different batches of the cream can have different proportions of bottles in which the active ingredient remains active.