RESEARCH ARTICLE

Understanding a science-themed puppet theatre performance for public engagement in Thailand [version 1; referees: awaiting peer review]

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Abstract

Background: Fishy Clouds, a 45-minute non-verbal touring puppet theatre show, was created with the objectives of (1) raising awareness of antimicrobial overuse and misuse (the fact that there simply is a problem), (2) raising awareness of the importance of research with children – including those involving antimicrobials, and (3) producing a science-themed performance of entertainment value and high artistic quality. The show used visual storytelling to bring the research and behaviour around antimicrobial resistance (AMR) to life for a broad range of audiences across different ages, locations, levels of education, and language.

Methods: In order to understand the effectiveness of Fishy Clouds, we used a realist-informed evaluation approach. A combination of quantitative and qualitative approaches (semi-structured interviews, focus group discussions and field notes) were used for data collection.

Results: We received a total of 880 quantitative feedback forms, conducted 22 semi-structured interviews and three focus group discussions. Our data showed that Fishy Clouds was an enjoyable performance to all audience groups and stakeholders and was generally viewed with artistic integrity. However, its effectiveness was primarily in raising existing awareness about medicine use and health more broadly, rather than specific health messaging concerning AMR and research with children. We found that those with limited background on AMR or research with children, such as school children and Karen ethnic migrants exhibited a wide range of interpretations. A science-themed theatre would function better if it is focussed on a single theme, embedded within a programme of activities and conducted at closed venues.

Conclusions: Fishy Clouds showed that science theatre events have the potential to support public health programmes and engage local communities in science research.
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Competing interests: PYC is the head of the department that commissioned the Fishy Clouds project and is the Principal Investigator of the evaluation study.

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Introduction
The Mahidol Oxford Tropical Medicine Research Unit (MORU) was established in 1979 as a research collaboration between Mahidol University in Thailand and University of Oxford in the United Kingdom. Among its new programme of public engagement activities\textsuperscript{4-4}, was a collaboration between MORU and B-floor Theatre, an avant-garde Thai theatre company, to produce a non-verbal performance with a combined theme of antimicrobial resistance (AMR) and research with children. This reflects the current national and international efforts to fight resistance to antimicrobials, such as drugs for malaria and tuberculosis, which has significant impacts on all levels of society with the largest impact on vulnerable groups such as children. These themes also reflect some of the research themes of MORU researchers and their collaborators\textsuperscript{5-6}. This project was also intended to coincide with the Thailand national AMR week, which was held between the 14\textsuperscript{th} and 20\textsuperscript{th} of November 2016. A non-verbal touring performance was chosen for the play to be accessible for children, those who are illiterate, and non-Thai-speaking audiences close to the border with Myanmar. We chose B-floor Theatre because they specialise in physical non-verbal theatre and we had previously successfully collaborated with them on a science theatre project called Survival Games.

The objectives of the performance were to (1) raise awareness of antimicrobial overuse and misuse (the fact that there simply is a problem), (2) raise awareness of the importance of research with children – including those involving antimicrobials (to help children themselves, provided that the research is useful, carefully thought out and ethical), and (3) produce a science-themed performance of entertainment value and high artistic quality.

In May 2016, the B-floor Theatre team started their research phase, which included conducting interviews with MORU scientists and others with interests and expertise in the themes of the production, such as farmers, parents, pharmacists and paediatricians. The B-floor Theatre team also attended meetings with the organisers of the national Thailand Antimicrobial Resistance Week 2016.

The resulting product was a 45-minute, puppet show entitled Fishy Clouds. The play was non-verbal, but it included live music whose story focused on antibiotic overuse (e.g. personal use, agricultural use) by the lead character, Don and the people around him, thereby contributing to antibiotic resistance (Supplementary File 1). An accompanying multi-lingual leaflet was produced to provide audiences with information about the storyline and the main themes of the play (Supplementary File 2). MORU researchers provided oversight of the scientific accuracy, but were not involved in the creative aspects of the play or the storyline.

The performances took place between 11\textsuperscript{th} November and 14\textsuperscript{th} December 2016 at nine venues, six in the Bangkok metropolitan area and three in Tak Province close to the Thai-Myanmar border. The venues included schools, theatres, healthcare centres and various open spaces. Some of the performances coincided with events, such as the AMR week launch in Thailand and a university open day. All eleven performances were free. Two performances were held in a theatre in Bangkok and were ticketed with a maximum number of 50 people at each performance. Other venues were open spaces, such as the waiting area of healthcare centres. The latter were not ticketed and numbers were unrestricted. These venues were chosen by both the MORU and B-floor Theatre teams to allow us to be inclusive and to reach a wide range of audience members, including those who do not normally go to see plays as a routine.

In order to understand the effectiveness of Fishy Clouds, we used a realist-informed evaluation approach\textsuperscript{10,11}. Rather than seeking a one-off verdict about the play’s average effect, as with traditional evaluation methods, realist research recognises that different audiences may react differentially to an intervention. Specifically, realist evaluation seeks to understand “what works for whom in what circumstances”\textsuperscript{10-12}. This framework provides an explanatory model that links the context, mechanism and outcome configurations, which are hypothesised prior to, or during the implementation of a project\textsuperscript{10,11}. Mechanisms “pertain(s) to what turns on in the minds of program participants and stakeholders that make them want to (for example) participate or invest in programs. They may be cognitive or emotional responses, typically in relation to program resources being offered”\textsuperscript{11}.

We were inspired by the realist framework because it could assess direct and indirect contribution of our intervention, whether intended or unintended. In addition, this approach offers the possibility to address short term changes, so we would be able to describe these changes after the performance. Another advantage is that this framework may increase our understanding regarding whether, how, and why the performance works or does not work. We would be able to differentiate if the intervention works for one group of audience whereas does not work for another group and why.

This paper describes the development of Fishy Clouds and the method and results of its evaluation.

Methods
Approval for the evaluation was obtained from the Oxford Tropical Research Ethics Committee (OxTREC Ref. 5125-16) and from the Faculty of Tropical Medicine Ethics Committee, Mahidol University (TMEC 16-102).

We identified four types of audience groups: (1) Bangkok theatre goers, (2) school children, (3) scientists and healthcare professionals, and (4) Karen and other ethnic migrants in Tak Province. In addition to audience groups, we identified two stakeholder groups: B-floor Theatre and MORU researchers.

Initial evaluation framework
Figure 1 shows the three objectives of Fishy Clouds and their related contexts, mechanism and outcomes of the initial evaluation framework\textsuperscript{10,12}.

Awareness raising: We theorised that generating awareness involves (1a) a growing interest in, (1b) a desire to learn more about, and (1c) reflection about one’s own ideas and values regarding AMR and research with children. We argued, after consulting
existing literature, that the principal mechanism underlying these outcomes is the stimulation of active thoughts through the creative expressions of the performance\textsuperscript{14,15}. The context of the intervention involved different venues as well as different educational and cultural background of the audiences, which may influence the audience’s ability to understand the messages of and reflect on the performance.

Artistic product: We identified two sets of outcomes for this objective, which are audience group outcomes and stakeholder outcomes. Project stakeholders relevant for this evaluation were MORU researchers and B-Floor Theatre team. Audience outcomes included (2a) the acknowledgment of the performances as “art” and (2b) a sense of enjoyment stemming from it, enacted by validating the performances through active appreciation\textsuperscript{16}. Stakeholder outcomes included (2c) the production of locally appropriate content, (2d) potentially sustainable relationships, and (2e) organisational sense of success. As for mechanism, we theorised that these outcomes are realised through the collaborative development of creative forms of expression between artistic and scientific project partners\textsuperscript{14,16}.

**Data collection**
We used a combination of quantitative and qualitative approaches for data collection.

A quantitative feedback form (Supplementary File 3) was adapted from an existing B-floor Theatre feedback form. Questions 1 to 3 of the feedback form relate to art and enjoyment outcomes (outcomes 2a and 2b), whereas questions 5 to 7 and 9 to 11 relate to the awareness raising outcomes (outcomes 1a, 1b and 1c). Wherever possible we distributed the feedback forms to all audience members.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Context</th>
<th>Mechanisms</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| **Objectives 1 & 2. Awareness raising**
- Antimicrobial resistance
- Research with children | Audience Composition
- Audience group differences
  - Cultural background
  - Education and awareness of subject
- Venues | Active Thought Process | 1a. Interest
1b. Desire to learn
1c. Reflection |
| **Objective 3. Artistic product**
- Artistic dimension
- Organisational process dimension | Audience Composition
- Audience group differences
  - Education
  - Subject awareness
  - Venues
  - Cultural background | Active appreciation | 2a. Validation as art
2b. Sense of enjoyment |
| Stakeholder Composition
  - Organisational backdrop
  - B-floor Theatre staff
  - MORU team | Collaborative process | 2c. Locally appropriate content
2d. Sustainable relationships
2e. Organisational sense of success |

![Figure 1. Initial evaluation framework.](image)
Semi-structured interviews and focus group discussions with audience members were conducted to aid the interpretation of the results of the feedback forms, whereas interviews with B-Floor Theatre and MORU staff were primarily aimed at assessing the collaboration aspect in the process of developing the play. Sampling for qualitative study was purposive to ensure that all audience member groups and stakeholder categories (B-floor Theatre and MORU staff) were included. All relevant documents were translated from English to Thai, Karen, and Burmese to be inclusive for potential participants. Field notes were collected during all performances.

Feedback forms were collected immediately after the shows by members of the study team. In the feedback forms, we asked participants who were willing to be contacted for interviews or focus group discussions to leave the contact details (Supplementary File 3).

Interviews and focus group discussions were conducted up to three weeks after each show by members of the study team.

Data analyses
Data from the feedback forms were entered in the MACRO V4 database, and analysed quantitatively, using descriptive statistical analysis. Audio recordings were transcribed verbatim, translated to English where necessary and analysed using thematic analysis. We had a combination of pre-existing themes based on the initial framework and emerging themes, particularly regarding context-mechanism-outcome configurations. Stata 13 was used for quantitative analysis, and NVivo 11 for qualitative analysis. In addition to the quantitative feedback questionnaire, field notes and qualitative interviews, we included two newspaper reviews published by theatre critics in the analysis.

Results and discussion

Approximately 1,500 people attended the performances and a total of 1,276 evaluation forms were distributed, of which 880 forms had partial or complete information. Table 1 describes the demographics of participants who completed the forms. Table 2–Table 4 show the results of the feedback forms by venues. We conducted 22 semi-structured interviews (14 audience members, 4 B-floor Theatre staff; 3 MORU staff members; 1 theatre critic) and three focus group discussions (school children, Bangkok theatre goers, and migrant workers in Tak Province). Interviews and focus groups discussions were conducted in Thai, English, and Karen according to the language preferred by the participants. Interviews and focus groups discussions lasted between 20 and 45 minutes each.

Awareness raising – outcomes 1a, 1b and 1c

The feedback forms (Q5–Q7, Q9–Q11) drew a positive picture in terms of audience member comprehension (above 70%, Table 3 and Table 4), but the qualitative evidence from the audience members indicated that interpretations can be various.

The overall response to the awareness-raising feedback form items was positive among all audience groups with 86.1% (Q5) reported to have an increased interest in medicine use, 81.9% (Q6) reported a desire to learn more about medicine and 78.6% (Q7) had a self-rated better understanding about medicine use. Research with children also received positive results with Q9 - 75.1%, Q10 - 76.7%, and Q11 - 78.3%, respectively. Audience members at the university open day event, which were majority school children aged 12–17 years old, responded most positively to the questions about awareness of AMR (Q5 - 93.9%, Q6 - 88.8%, and Q7 - 90.8%), while the lowest response was from attendees at the international tropical medicine conference (Q5 - 66.7%, Q6 - 73.3%, and Q7 - 50.0%), who were primarily researchers and doctors. Attendees at the AMR day responded most positively to the questions about awareness of research with children (Q9 - 90.6%, Q10 - 90.6%, and Q11 - 84.4%), while the lowest response was from those at the tropical medicine conference (Q9 - 50.0%, Q10 - 53.3%, and Q11 - 53.3%). The drama increased interest in research with children among all types of audience except for attendees at the tropical medicine conference (Q8 - 50.0%, Q9 - 50.0%).

Qualitative data illustrated that Fishy Clouds was effective primarily in raising existing awareness about medicine use and health more broadly rather than specific health messaging concerning AMR and research with children.

“I think [I want to learn more about] antibiotics – […] how many types there are and what types that … in fact the medicines that we take every day or even our food, they never tell us about the ingredients.” (male Bangkok theatre goer, 40 years, high school education, semi-structured interview).

As far as the specific messages are concerned, one of the reviewers wrote, “award winning young playwright Pattareeya Puaponsakorn’s script for this 45-minute non-verbal performance was easy to understand and straight to the point – and the accompanying leaflet made sure that the audience could share this information with others as well.”

However, a handful of audience members appeared to have misunderstood the messages of the play. For example:

“This drama teaches me that if I don’t take the medicines, the germs will increase and make us sick, then we would have to take even more medicines and get injections and take 3–4 pills every day. So I’m scared. And from then on, I take all the medicines.” (female student, 14 years, focus group discussion with school children).

As the play was non-verbal, this misunderstanding may have arisen from lack of background knowledge or that the information in the leaflet was not read, the latter frequently observed by the team during the performances.

Artistic product - outcomes 2a and 2b

Our theory is that the key mechanism to realising outcomes 2a (validation as art) and 2b (sense of enjoyment) is active appreciation of the show (Figure 2). We were interested in audience as well as critics’ views about the artistic nature of the production. Although the artistic value received mixed reviews, audience members and critics thought the play was entertaining. The play also appeared to have the added value of having a potentially positive influence on promoting art and theatre locally.
Table 1. Demographics data for those who completed the evaluation form across venues.

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<th>MKT Migrant Clinic, Thai-Myanmar Border</th>
<th>NH Primary School, Bangkok</th>
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<th>TU university Open Day, Bangkok (2 performances)</th>
<th>Democrazy theatre studio, Bangkok (2 performances)</th>
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<th>Local healthcare conference, Thai-Myanmar border</th>
<th>CTE School, Bangkok</th>
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**Education**

| None           | 9                                      | 1.0                                     | 7                          | 10.6                                                    | 2                                               | 2.1                                               | 0                                             | 0.0                                               | 0                   | 0.0                                             | 0                   | 0.0                                             | 0                   | 0.0                                             | 0                   | 0.0                                             | 0                   | 0.0                                             |
| Primary        | 418                                    | 47.5                                    | 21                         | 31.8                                                    | 66                                               | 68.0                                              | 15                                            | 23.8                                              | 0                   | 0.0                                             | 2                   | 2.0                                             | 10                  | 12.2                                           | 0                   | 0.0                                             | 1                   | 1.0                                             | 303                | 96.5               |
| Secondary      | 221                                    | 25.1                                    | 24                         | 36.4                                                    | 14                                               | 14.4                                              | 16                                            | 25.4                                              | 4                   | 12.5                                            | 89                  | 90.8                                            | 13                  | 15.9                                           | 0                   | 0.0                                             | 58                  | 59.2                                           | 3                   | 1.0                |
| Undergraduate  | 86                                     | 9.8                                     | 1                          | 1.5                                                     | 5                                                | 5.2                                               | 17                                            | 27.0                                              | 12                  | 37.5                                            | 3                   | 3.1                                             | 33                  | 40.2                                           | 4                   | 13.3                                           | 11                  | 11.2                                           | 0                   | 0.0                |
| Graduate and Above | 67                     | 7.6                                     | 0                          | 0.0                                                     | 0                                                | 0.0                                               | 8                                             | 12.7                                              | 13                  | 40.6                                            | 1                   | 1.0                                             | 13                  | 15.9                                           | 19                  | 63.3                                           | 13                  | 13.3                                           | 0                   | 0.0                |
| Unknown        | 79                                     | 9.0                                     | 13                         | 19.7                                                    | 10                                               | 10.3                                              | 7                                             | 11.1                                              | 3                   | 9.4                                             | 3                   | 3.1                                             | 13                  | 15.9                                           | 7                   | 23.3                                           | 15                  | 15.3                                           | 8                   | 2.5                |
Table 2. Art-related evaluation form responses across venues.

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Total</th>
<th>WP Migrant Clinic, Thai-Myanmar Border</th>
<th>MKT Migrant Clinic, Thai-Myanmar Border</th>
<th>NH Primary School, Bangkok</th>
<th>Antimicrobial Resistance Day Opening Ceremony, Bangkok</th>
<th>TU university Open Day, Bangkok (2 performances)</th>
<th>Democrazy theatre studio, Bangkok (2 performances)</th>
<th>Local healthcare conference, Thailand-Myanmar border</th>
<th>CTE School, Bangkok</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Total</td>
<td>880</td>
<td>100.0</td>
<td>66</td>
<td>7.5</td>
<td>97</td>
<td>11.0</td>
<td>63</td>
<td>7.2</td>
<td>32</td>
</tr>
<tr>
<td>Q1 How do you feel about the drama?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Like it</td>
<td>817</td>
<td>92.8</td>
<td>59</td>
<td>89.4</td>
<td>87</td>
<td>89.7</td>
<td>63</td>
<td>100.0</td>
<td>28</td>
</tr>
<tr>
<td>Don’t like it</td>
<td>15</td>
<td>1.7</td>
<td>1</td>
<td>1.5</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
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<tr>
<td>Don’t know</td>
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<td>2</td>
<td>3.0</td>
<td>6</td>
<td>6.2</td>
<td>0</td>
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<td>3</td>
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<tr>
<td>Unknown</td>
<td>16</td>
<td>1.8</td>
<td>4</td>
<td>6.1</td>
<td>4</td>
<td>4.1</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>Q2 Do you think this is art?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>699</td>
<td>79.4</td>
<td>43</td>
<td>65.2</td>
<td>71</td>
<td>73.2</td>
<td>55</td>
<td>87.3</td>
<td>31</td>
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<tr>
<td>No</td>
<td>75</td>
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<td>15</td>
<td>22.7</td>
<td>3</td>
<td>3.1</td>
<td>2</td>
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<td>0</td>
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<tr>
<td>Don’t know</td>
<td>87</td>
<td>9.9</td>
<td>3</td>
<td>4.5</td>
<td>19</td>
<td>19.6</td>
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<td>4</td>
<td>4.1</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>Q3 Did you find any element of this drama related to your culture?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>546</td>
<td>62.0</td>
<td>39</td>
<td>59.1</td>
<td>58</td>
<td>59.8</td>
<td>53</td>
<td>84.1</td>
<td>25</td>
</tr>
<tr>
<td>No</td>
<td>141</td>
<td>16.0</td>
<td>14</td>
<td>21.2</td>
<td>12</td>
<td>12.4</td>
<td>4</td>
<td>6.3</td>
<td>3</td>
</tr>
<tr>
<td>Don’t know</td>
<td>170</td>
<td>19.3</td>
<td>7</td>
<td>10.6</td>
<td>21</td>
<td>21.6</td>
<td>6</td>
<td>9.5</td>
<td>4</td>
</tr>
<tr>
<td>Unknown</td>
<td>23</td>
<td>2.6</td>
<td>6</td>
<td>9.1</td>
<td>6</td>
<td>6.2</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2136</td>
<td>222.7</td>
<td>271.4</td>
<td>262.5</td>
<td>269.4</td>
<td>251.2</td>
<td>213.3</td>
<td>232.7</td>
<td>219.1</td>
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<tr>
<td>Average</td>
<td>71.2</td>
<td>74.2</td>
<td>90.5</td>
<td>87.5</td>
<td>89.8</td>
<td>83.7</td>
<td>71.1</td>
<td>77.6</td>
<td>73.0</td>
</tr>
</tbody>
</table>
Table 3. Antimicrobial resistance-related evaluation form responses across venues.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
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<td>n %</td>
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<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Total</td>
<td>880</td>
<td>100.0</td>
<td>66.7</td>
<td>97.1</td>
<td>63.2</td>
<td>7.2</td>
<td>98.1</td>
<td>11.1</td>
<td>82.0</td>
<td>9.3</td>
</tr>
</tbody>
</table>

Q4 Before watching the drama, were you interested in the correct use of medicines?

- Yes 651 (74.0)
- No 91 (10.3)
- Don’t know 107 (12.2)
- Unknown 31 (3.5)

Q5 Did the drama increase your interest in the correct use of medicines?

- Yes 758 (86.1)
- No 50 (5.7)
- Don’t know 58 (6.6)
- Unknown 14 (1.6)

Q6 Do you want to learn more about the correct use of medicines?

- Yes 721 (81.9)
- No 49 (5.6)
- Don’t know 85 (9.7)
- Unknown 25 (2.8)

Q7 Did the drama give you new ideas regarding the correct use of medicines?

- Yes 692 (78.6)
- No 72 (8.2)
- Don’t know 91 (10.3)
- Unknown 25 (2.8)

Total

- 246.7
- 251.5
- 244.3
- 261.9
- 246.9
- 273.5
- 248.8
- 190.0
- 239.8
- 242.0

Average

- 82.2
- 83.8
- 81.4
- 87.3
- 82.3
- 91.2
- 82.9
- 63.3
- 79.9
- 80.7
Table 4. Research with children-related evaluation form responses across venues.

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
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<td>n %</td>
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<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Total</td>
<td>880 100.0</td>
<td>66 7.5</td>
<td>97 11.0</td>
<td>63 7.2</td>
<td>32 3.6</td>
<td>98 11.1</td>
<td>82 9.3</td>
<td>30 3.4</td>
<td>98 11.1</td>
</tr>
</tbody>
</table>

Q8 Before watching the drama, were you interested in the participation of children in research?

- Yes: 515 (58.5%)
- No: 178 (20.2%)
- Don’t know: 164 (18.6%)
- Unknown: 23 (2.6%)

Q9 Did the drama increase your interest in the participation of children in research?

- Yes: 661 (75.1%)
- No: 68 (7.7%)
- Don’t know: 123 (14.0%)
- Unknown: 28 (3.2%)

Q10 Do you want to learn more about the participation of children in research?

- Yes: 675 (76.7%)
- No: 74 (8.4%)
- Don’t know: 105 (11.9%)
- Unknown: 26 (3.0%)

Q11 Did the drama give you new ideas regarding the participation of children in research?

- Yes: 689 (78.3%)
- No: 58 (6.6%)
- Don’t know: 115 (13.1%)
- Unknown: 18 (2.0%)

**Total**

- 247.0
- 218.6
- 233.3
- 265.6
- 257.1
- 228.0
- 156.7
- 243.9
- 220.7

**Average**

- 82.3
- 72.9
- 77.8
- 88.5
- 85.7
- 76.0
- 52.2
- 81.3
- 73.6
Questions 1 to 3 in the feedback forms asked what the audience thought about the play (see Table 2). The first question (Q1) in the feedback forms asked the audience how they felt about the drama, with 92.8% answering that they “like it”. The second question (Q2) asked whether they think it is art, with 79.4% agreeing that it is. The third question (Q3), which asked if the elements of the play relate to the audience’s culture, received a lower response of 62.0% overall.

The highest level of approval came from school children, in particular from the NH and CTE schools with 100% and 94.3%, respectively. The artistic value of Fishy Clouds was most highly appreciated by those who attended the AMR day and at TU university, where 96.0% of respondents identified it is art in the feedback forms. Migrant workers in Tak province produced the lowest responses, with only 73.2% in MKT, and 65.2% in WP clinics considering the show as art. Unsurprisingly, the migrant workers who were primarily ethnic Karen, also indicated a relatively weak relationship between the elements of the drama and their own culture (59.1% and 59.8% in WP and MKT, respectively). The CTE school, located in a Muslim community, also had a low response, with only 50.6% that found the play relating to their culture. This potentially stems from the difference in cultural background. A play developed by a Bangkok-based Thai theatre group may not be relatable to Myanmar ethnic or Muslim minority groups.

The comparatively low overall rating among migrant workers in Tak Province may suggest that some audience members viewed the play as health promotion instead of art. For instance, a migrant
worker in Tak Province explained that the show was not art because it "...demonstrated illness and different kinds of symptoms..." (male migrant, 53 years, primary education, semi-structured interview). Another migrant worker who said he enjoyed the show explained in a focus group discussion that the play was “knowledge” instead of art. This suggests that for some audience members, entertainment value arose from the subject matter and information sharing instead of appreciation of the art and talent of the performers.

“In the beginning I was not interested because the big fish came out and I thought it was a show for small children, and later as I continued watching I understood that it was related to taking medicines and I became interested.” (female migrant worker, focus group discussion, age not available, high school education).

Many audience members enjoyed the life-size puppets, live music and comedy aspects of the play.

“I’ve always liked puppets. [...] Especially with something very academic, if I had to only sit and listen, I would fall asleep. But when they make the story interesting by sharpening it with art, I feel that it’s... it’s got more to offer. It’s enthralling.” (female Bangkok theatre goer, 40 years, high school education, semi-structured interview).

I went to see with the kids. I want to know their interests because the performers, I watched the facial expressions and props – the props they make – because the kids were very interested in those so I went to see with the kids. I want to know their interests because when they have an interest, they’ll pick that up and apply it.” (male Bangkok theatre goer, 40 years, high school education, semi-structured interview).

The play also had a potential additional positive influence on promoting art and theatre locally.

“I think the puppets were interesting because the school [my son is attending] is also starting to make puppets. They have different methods. It was the puppets and the music that I went to see after the show ended. [...] But when I watched [the show,] I didn’t watch the performers, I watched the facial expressions and props – the props they make – because the kids were very interested in those so I went to see with the kids. I want to know their interests because when they have an interest, they’ll pick that up and apply it.” (male Bangkok theatre goer, 40 years, high school education, semi-structured interview).

The quote supports our hypothesis that the underlying mechanism was stimulation of active thoughts. Fishy Clouds was not only artistic and entertaining but it also has the potential to provide inspiration for future artistic endeavours.

“[Fishy clouds] includes creativity. It includes colours. There’s a whole scenario. And even though there’s a scientific, like health-related message that you don’t decide, of course, that is based on evidences. There’s still a part to know how to make the message, how to transmit it. So, it’s about creativity. It’s about imagination. It’s about trying to inspire people. And so, of course, it’s art. Yes, it is.” (male MORU PhD student, 33 years, semi-structured interview).

**Collaborative production – outcomes 2c, d and e**

We also considered stakeholder outcomes resulting from the arts-science collaboration. The relevant outcomes in our evaluation framework were (2c) the production of a locally appropriate science-themed drama, (2d) potential for sustained relationships between the arts and the sciences, and (2e) a shared sense of organisational learning and success. This section demonstrates the overall project success with respect to the collaborative production (2d and 2e), but cost-effectiveness (2d) and appropriateness of the play for certain audience groups (2c) were questioned. As far as the process itself is concerned, MORU and B-floor Theatre staff acknowledged that the collaborative production was useful and enjoyable:

“During the research process, we worked with the research team and met with different doctors that work in this field. And then we also worked with the playwright, yes, to like, to identify the topic that we’re interested in from the research process with the doctors.” (male actor, B-Floor Theatre, 26 years, semi-structured interview).

“I think I quite like it [the process] in the way that they [B-Floor Theatre] tried to get a lot of researchers, they ask all stakeholders as much as they can and I point to the outside doctors outside of Thailand, the pharmacies, the activist[s] who work on this area and they try to research everything.” (senior male senior researcher, MORU, 38 years, semi-structured interview).

Stakeholders perceived the relationships created and reinforced by this project as potentially sustainable (2d), reinforcing the positive collaborative experience.

The following quotes illustrate the potential for future collaborations: "I hope MORU and Wellcome Trust [are] up for it” (senior B-Floor Theatre team, semi-structured interview); “possible if both sides want to” (senior male senior researcher, MORU, 38 years, semi-structured interview). This suggests that the project was successful in developing potentially sustainable relationships between the MORU and B-Floor Theatre. Indeed, MORU are hoping to collaborate with B-Floor Theatre again in 2018.

As for the production of locally appropriate content (2c), most stakeholders viewed that the content was appropriate although a little bit too abstract and the narrative was difficult to follow. The theatre group members emphasised that like any piece of art, it was up to the audience to interpret the art, a notion that was quite challenging to MORU scientists. They also said they there were many logistical and technical challenges related to the non-verbal and touring nature of production.

Theatre staff and scientists understood that venues and audience group differences (e.g. different age groups, cultural and educational backgrounds) could influence the successful delivery of the drama’s messages. They also acknowledged that the audience might require a background knowledge of the topic and that it is unrealistic that one-off play will be successful in delivering complicated concepts.

Theatre and MORU stakeholders suggested the play would have benefited from complementary information and a discussion of the artistic and scientific content before and after the show. They also noted that it was more difficult to convey the play’s messages in open spaces where not everyone watched the play from beginning to the end.
While almost everyone enjoyed watching the life-size puppets and live music, some MORU stakeholders questioned if they are the most suitable or cost-effective way to convey complex scientific topics such as AMR and research with children. Some researchers viewed that it was ambitious to combine AMR and research with children, both complicated subjects.

Most stakeholders maintain the position that it was unrealistic that a single performance can suit all audience types – children, adults, migrants and theatre enthusiasts. This also fits with the realist concept that the same intervention may have differential outcomes for different target populations, in this case, audience members, depending on the extent to which the “active ingredient” or mechanism is triggered for the context of different audience groups.

Augmented framework

Figure 2 depicts the augmented evaluation framework informed by our data. For the awareness raising objective, our data suggested that inter-related elements within the mechanism of active thought processes to raise awareness include the following: recognising the topic area within the creative expression, relating the story to background knowledge and education, and interpreting both the written and non-verbal messages in the performance. These elements of the thought process interact with characteristics of the audience, including their background knowledge of the subjects and their cultural background. In addition we noted that the performance venue, as well as how much the complementary information was utilised influenced the interpretation of the awareness-related outcomes and potentially contribute to misunderstanding of the intended messages.

As for the artistic product, our data suggest that the mechanisms underlying the active appreciation were: audience members’ conceptualisation of art and health education, the presence of artistic elements to increase attention and appreciation; and inspiration following exposure to the performance. Our data showed that apart from appreciation of the performance as art and enjoyment of the play, the performance also could play a part in the promotion of the arts.

We considered balancing the interests of the stakeholders and mutual learning as important components of the mechanism of collaborative process aimed at production of locally appropriate content, sustainable relationships, and an organisational sense of success. We see organisational learning not only a process in itself but also a desirable outcome in our science-arts collaboration.

Challenges

The team encountered several challenges in the development of Fishy Clouds, as well as the evaluation. The B-floor Theatre team were granted the artistic freedom to create the performance with scientific guidance from the MORU staff. MORU staff provided oversight in order to ensure scientific accuracy but had no input in the creative process. The collaboration was challenging for scientists who were inclined towards health messaging, such as asking audience members to not take antibiotics for viral fevers instead of merely raising awareness. Another challenge during the development of Fishy Clouds was to strike a balance between the awareness raising objective and the artistic objective.

With the passing of King Bhumibol Adulyadej of Thailand in October 2016, and the resulting nationwide mourning period, the initial performances of Fishy Clouds had to be delayed. This proved challenging to cancel and reschedule these performances and find alternative venues. As a result, our performance venues were chosen primarily based on availability of the performers and venues rather than target audience groups.

The play itself was visually strong, but informal feedback with audience members during the first few performances revealed that there was a feeling that the narrative could have been challenging for some viewers to understand. In response to this, a very basic synopsis (Supplementary File 1) was created in Thai, English, Burmese and Karen and was distributed with the leaflet at the start of each show. The later shows also included a short talk about AMR and research with children by a MORU staff member to orientate the audience.

Another challenge was that we encountered some delays in the ethics approvals, which meant that the qualitative part of the work was only conducted several weeks after the performances resulting in possible recall bias. This also resulted in a temporal mismatch between the feedback forms and the qualitative data.

As with most health research, written consent for participation in the qualitative interviews was required. This requirement resulted in delays in conducting interviews with children as we had to wait for the children to ask their parents to sign the consent forms at home.

Because the audiences included Thai, English, Burmese and Karen speaking people, it was necessary to have four different versions of the feedback forms and interview guides, which was a logistical challenge. Interviews also needed to be translated, both as the interviews were being conducted and afterwards for analysis. This also increased the cost of the evaluation initiative substantially.

Limitations

Our evaluation had several limitations. For our feedback forms, we had to compromise having detailed feedback for brevity and ease of administration.

For venues that were open, it was not possible to determine if an audience member watched the entire performance, so if an audience member did not understand the messages of the play, we did not know if it was because the messages were not clear or that they only watched the play partially.

Our study was focussed narrowly on the specific objectives of the live performance and the evaluation period was limited to the project period. B-floor Theatre created a Youtube video of the show and shared it widely. The Fishy Clouds project was part of a wider programme that coincided with the AMR week in Thailand in 2016. We did not evaluate the impact of the video or the wider
or longer term implications of the project, such as the publicity and media coverage that the shows generated.

We also acknowledge that the evaluation team was not completely independent from the team that commissioned Fishy Clouds.

Conclusions
The realist evaluation found that those with limited background on AMR or research with children, such as school children and Karen ethnic migrants on the Thai-Myanmar border, exhibited a wide range of interpretations. A science-themed theatre would function better if it is embedded within a programme of activities, which could include information campaigns. For future projects, we could collaborate with schools or existing healthcare institutions to offer an extended series of activities rather than isolated, one-off events. Future projects should consider narrowing the scientific focus and target audience groups, and taking into consideration the target groups’ background knowledge, existing conceptions and exposure to the topic. If possible, the performances should be conducted in closed spaces to increase the likelihood that audiences watch the performances from beginning until the end without interruption and that they participate in related discussions.

As expected, most scientists and healthcare professionals did not report that they had an increase of awareness of the subjects discussed in Fishy Clouds but rather, found the play entertaining and inspiring.

Bangkok theatre goers who had comparatively higher education and went to see the play at a closed theatre appeared more likely to reflect on and understand the messages of the play.

Our data showed that Fishy Clouds was an enjoyable performance to all audience groups and stakeholders and was generally viewed with artistic integrity. However, its effectiveness was primarily in raising existing awareness about medicine use and health more broadly, rather than specific health messaging concerning AMR and research with children.

Fishy Clouds showed that science theatre events can support public health programmes and engage local communities in science research. The realist approach of ‘what works for whom, in what context’ could be utilised to inform public engagement strategies in the future.

Ethical statement
Approval for the evaluation was obtained from the Oxford Tropical Research Ethics Committee (OxTREC Ref. 5125-16) and from the Faculty of Tropical Medicine Ethics Committee, Mahidol University (TMEC 16-102). Verbal informed consent was obtained for the quantitative feedback forms in accordance to OxTREC and local guidelines; feedback forms were handed out at the end of performances and everyone who wished to participate completed the forms. Written informed consent was obtained from those participating in the qualitative study.

Data availability
Due to ethical and security considerations, the data that supports the findings in this study (quantitative data from feedback forms and qualitative data) can be accessed only through the Data Access Committee at Mahidol Oxford Tropical Medicine Research Unit (contact facilitated through phaikeong@tropmedres.ac). The data sharing policy can be found here: http://www.tropmedres.ac/data-sharing. The application form for datasets under the custodianship of MORU can be found in Supplementary File 4.

Author contributions
The Fishy Clouds project was commissioned by the Department of Bioethics & Engagement of MORU headed by PYC. The evaluation was led by PYC, LSI and AH participated in this project as part of a three-month internship. Quantitative data was collected and analysed by LSI, NC, NJ, PW, AH and NHK. Interviews and focus group discussions were conducted by PYC, LSI, AH, NC, NJ, NK and PW. Field notes were taken by LSI, NC, NJ and AH. Translations and transcriptions were conducted by NJ, AH, PW, NK and NC. Qualitative data analysis was conducted by NC, NJ and PYC. ER guided the realist analysis.

Competing interests
PYC is the head of the department that commissioned the Fishy Clouds project and is the Principal Investigator of the evaluation study.

Grant information
Fishy Clouds and its evaluation was funded by a Wellcome Trust Provision for Public Engagement grant (106698) and Oxford’s Public Engagement with Research Seed Fund (supported by Oxford’s RCUK Catalyst Seed Fund Award).

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Acknowledgements
The authors thank our senior evaluation consultant Marco J. Haenssgen for guidance on evaluation methodology, design of the evaluation project, co-supervision of the evaluation interns, supervision of the evaluation implementation and data collection process, and for an internal draft report of the findings. The authors thank B-Floor Theatre for providing the space for this evaluation, and all interviewees and audience members for sharing their experiences with us. We also thank Nicholas Day, Direk Limmathurotsakul, Yoel Lubell, Abby Taylor and Thomas Althaus from MORU for their input in the development of Fishy Clouds. We are grateful to the organisers of the Thailand AMR week 2016 for their support in facilitating the performances at the AMR week.

Declarations
Sections of this paper were drawn from internship evaluation reports (by AH and LSI); the full internal evaluation report led by Marco J. Haenssgen and an online report for The Global Health Network available here: https://mesh.tghn.org/articles/project-report-fishy-clouds/.
**Supplementary material**

**Supplementary File 1:** Synopsis of Fishy Clouds.

Click here to access the data.

**Supplementary File 2:** Multi-lingual leaflet for audiences with information about the storyline and the main themes of the play.

Click here to access the data.

**Supplementary File 3:** B-Floor Theatre Fishy Clouds feedback form in English and Thai.

Click here to access the data.

**Supplementary File 4:** Application Form for datasets under the custodianship of Mahidol Oxford Tropical Medicine Research Unit (MORU) Tropical Network.

Click here to access the data.

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**References**

20. Pongpipat K: When medicine is the problem, not the cure. Bangkok Post; 2016. Reference Source