



## **Cost-effectiveness of 'screen-and-treat' interventions for post-traumatic stress disorder following major incidents**

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# BMJ Open Cost-effectiveness of 'screen-and-treat' interventions for post-traumatic stress disorder following major incidents

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## ABSTRACT

**Objectives** Post-traumatic stress disorder (PTSD) is commonly experienced in the aftermath of major incidents such as terrorism and pandemics. Well-established principles of response include effective and scalable treatment for individuals affected by PTSD. In England, such responses have combined proactive outreach, screening and evidence-based interventions (a 'screen-and-treat' approach), but little is known about its cost-effectiveness. The objective of this paper is to report the first systematic attempt to assess the cost-effectiveness of this approach.

**Methods** A decision modelling analysis was undertaken to estimate the costs per quality-adjusted life-year (QALY) gained from a screen-and-treat approach compared with treatment-as-usual, the latter involving identification of PTSD by general practitioners and referral to psychological therapy services. Model input variables were drawn from relevant empirical studies in the context of terrorism and the unit costs of health and social care in England. The model was run over a 5-year time horizon for a hypothetical cohort of 1000 exposed adults from the perspective of the National Health Service and Personal Social Services in England.

**Results** The incremental cost per QALY gained was £7931. This would be considered cost-effective 88% of the time at a willingness-to-pay threshold of £20 000 per QALY gained, the threshold associated with the National Institute for Health and Care Excellence in England. Sensitivity analysis confirmed this result was robust.

**Conclusions** A screen-and-treat approach for identifying and treating PTSD in adults following terrorist attacks appears cost-effective in England compared with treatment-as-usual through conventional primary care routes. Although this finding was in the context of terrorism, the implications might be translatable into other major incident-related scenarios including the current COVID-19 pandemic.

## INTRODUCTION

Post-traumatic stress disorder (PTSD), a severe and chronic condition associated with high levels of functional impairment, is the most common single psychiatric outcome of major incidents worldwide, including pandemics.<sup>1–4</sup> Following exposure to a terrorist attack, for example, adult victims

## Strengths and limitations of this study

- Emerging economic data on screen-and-treat programmes are synthesised for the first time.
- The model is based on actual clinical practice and closely follows National Institute for Health and Care Excellence guidelines.
- Exclusion of indirect costs may have led to underestimation of the cost-effectiveness of the screen-and-treat approach.

have a prevalence of PTSD estimated at 30%–40%.<sup>5</sup> Despite the existence of effective psychological therapies, PTSD often remains untreated, whether or not it occurs in the context of a major incident.<sup>6–8</sup> The reasons for this are well understood: a combination of low priority at strategic planning and policy development level, general low levels of public understanding, poor recognition in primary care and the avoidance that is one of the defining symptoms.<sup>6–9 10</sup> In recent years, health systems have begun to address this problem by instituting proactive outreach to affected populations, often coupled with screening and signposting into evidence-based treatments.<sup>11–14</sup> In this paper, we report the first systematic attempt to assess the cost-effectiveness of this approach. Data are taken from studies of terrorist attacks affecting UK residents, but our conclusions provide some implications for other major incidents and can inform responses to COVID-19 where PTSD is a common problem.<sup>15</sup>

It is important to highlight upfront that psychological reactions to trauma vary in severity and duration. The majority of individuals directly exposed to trauma will not develop PTSD, as many symptoms of distress will naturally decline and are unlikely to have long-term implications.<sup>15</sup> A sizeable minority require mental health services and a small proportion need long-term intervention.

In England, the public health approach following recent major incidents has been to institute an initial period of ‘watchful waiting’, which for the majority will allow natural coping resources and social support to lead to spontaneous remission and mitigates the deployment of resources on individuals with transient conditions. After this initial delay, outreach and screening are offered to populations at high risk of developing PTSD. This is done using brief, validated instruments.<sup>16</sup> A stepped model of care is recommended, which starts with assessment and facilitates access to mental health services if immediate and short-term distress does not resolve. Trauma-focused cognitive behavioural therapy (CBT) is a highly effective treatment for PTSD, typically delivered over 8–12 sessions.<sup>17</sup> Approaches that link evidence-based treatment with outreach and screening are known as ‘screen-and-treat’ or ‘outreach-and-screen’.

There have been several bespoke screen-and-treat programmes implemented in England in the context of recent major incidents. These include the Trauma Response Programme following the London bombings, the Screen and Treat Programme following the terrorist attacks in Tunisia, Brussels and Paris, the Manchester Resilience Hub following the Manchester Arena bombing and the Health and Well-being Service after the Grenfell Tower fire in West London. Evaluations of those programmes have concluded that screen-and-treat approaches may be a clinically effective approach for decreasing symptoms of mental ill health and improving social function following major incidents.<sup>13 18–22</sup>

Economic modelling can be used to synthesise evidence on the effectiveness of different interventions with evidence on the costs and consequences of these actions. The approach is used as standard by the National Institute for Health and Care Excellence in England (NICE) when looking at the case for investing in any healthcare intervention. Assumptions in models can be varied to help provide decision makers with a range of policy-relevant information, including uncertainty on evidence of effect, as well as level of uptake and sustained use. Models can also be used to extrapolate longer-term impacts than those seen in many empirical trials.

With screen-and-treat approaches, evidence on cost-effectiveness as well as clinical effectiveness is vital to support decisions on both short-term and longer-term resourcing. The aim of our study is to use decision analytical modelling to evaluate the cost-effectiveness of a screen-and-treat approach for identifying and treating PTSD following major incidents compared with treatment-as-usual delivered as a result of identification through conventional primary care routes and subsequent referral to the same psychological therapy services.

## METHODS

### Study design and assumptions

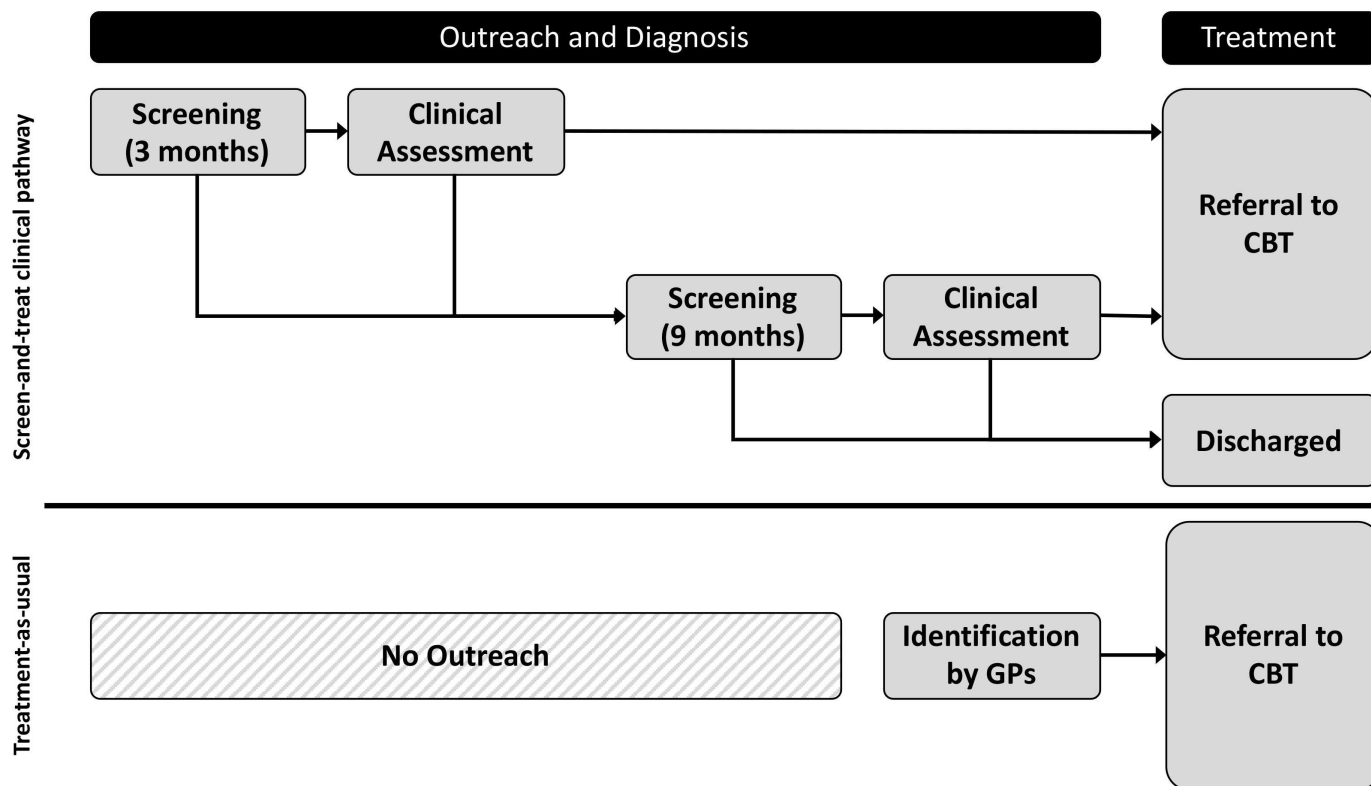
A decision tree was constructed in Microsoft Excel to compare the screen-and-treat approach with

treatment-as-usual for a hypothetical cohort of individuals in England. Each pathway was assumed to consist of 1000 adults who were directly exposed to terrorism at time zero. The clinical pathway for the screen-and-treat intervention group was based on a simplified version of the mental health responses implemented following the London bombings in 2005 and 2017. The intervention pathway assumed that individuals were screened with the Trauma Screening Questionnaire (TSQ) at 3 months.<sup>23</sup> The intervention pathway compared with treatment-as-usual is shown in figure 1. It was not necessary to incorporate Markov cycles into the model as participants were unlikely to move any further between states after the initial period when treatment had been completed. Any spontaneous remission we also assumed would only occur in this period.

Participants who screened positive would have a clinical assessment in the form of the Structured Clinical Interview for DSM-5 (SCID-5).<sup>24</sup> This is a commonly employed measure and assumed to be 100% accurate. Individuals identified as ‘true positives’ would then be referred for CBT mainly through Improving Access to Psychological Therapies (IAPT) services, receiving an average of 12 individual weekly sessions over 3 months.<sup>25</sup> Rates of uptake and completion of CBT were modelled separately. The ‘false positives’, those incorrectly identified by the screening tool, were screened out by the SCID-5 as they did not have PTSD. Subsequently at 9 months, all participants in the intervention pathway who had not been referred to treatment were screened again using the TSQ in an attempt to capture the ‘false negatives’ from the first round of screening as well as those participants that developed delayed-onset PTSD. The process of assessment used the SCID-5 and again referral for treatment with CBT was offered.

The treatment-as-usual comparator group received no treatment, unless the individual was detected as having PTSD through conventional primary care routes. Participants in the comparator pathway with PTSD who were detected in primary care were also referred to IAPT services for treatment. At the end of the clinical pathway, the proportions of participants in the intervention and comparator groups with PTSD, partial recovery from PTSD, and no PTSD were calculated. Partial recovery from PTSD was a health state intended to reflect those individuals experiencing symptoms at a subclinical level.

Costs and outcomes conditional on the individual’s health state were simulated over a 5-year time horizon from a National Health Service (NHS) and Personal Social Services (PSS) perspective to capture the longer-term and wider consequences of PTSD. This is the perspective adopted by NICE in their appraisals. Five years is a plausible time frame as we expect some persistence of effect.<sup>18</sup> All costs were inflated by 1.5% annually to 2018 prices in British Pounds (GBP) and both costs and outcomes were discounted over the 5-year time horizon at 3.5% per annum. This discount rate was chosen to reflect central government guidance on appraisal and evaluation.<sup>26</sup>



**Figure 1** Screen-and-treat clinical pathway compared with treatment-as-usual. CBT, cognitive-behavioural therapy; GPs, general practitioner.

It was conservatively assumed that PTSD was the only mental health impact, and comorbidity with other mental health conditions was not modelled. This simplification was made because, although comorbidity is high in psychiatric samples with PTSD and survivors of chronic and repeated trauma, there is no evidence this applies to victims of terrorist attacks who are more representative of the general population. In any event, PTSD represents the overwhelming majority of mental health need following terrorism and successful treatment for PTSD also leads to remission of comorbid conditions.<sup>5 11 27</sup> The model was further simplified to ignore the risk of relapse because gains from CBT tend to be maintained following a single trauma.<sup>18 28</sup> Furthermore, the model did not account for heterogeneity by demographic factors (eg, age, sex, ethnicity and socioeconomic status). Incremental cost per quality-adjusted life-year (QALY) was then calculated. This is the reference case measure used by NICE when assessing the case for investing in healthcare interventions and enables comparison between investment choices for different healthcare and public health programmes.

### Model parameters

Model inputs are shown in table 1. Where possible, the most relevant ‘local’ parameter estimates were used. The prevalence of PTSD in adults was assumed to be 31% based on the proportion of survivors that required treatment for PTSD following the London bombings.<sup>18</sup> This is consistent with an international systematic review finding a mean prevalence of 29.8% in adult victims of

terrorism.<sup>29</sup> Furthermore, it was assumed that for 85% of participants the onset of PTSD would be ‘immediate’ (occur within 3 months) and the remaining 15% would have a ‘delayed’ onset (at 6 months). This is consistent with evidence on the prevalence of delayed-onset PTSD.<sup>30</sup>

Studies analysing data from the London bombings were used to estimate the specificity and sensitivity of the TSQ at 3 months and 9 months<sup>31</sup> and the probabilities of uptake of CBT, completion of CBT and recovery or partial recovery with CBT.<sup>18</sup> The underlying annual risk of mortality in both arms of the model was assumed to be equivalent to the weighted average of rates for males and females at age 40 in England.<sup>32</sup> We assumed a 54% increased risk of all-cause mortality due to PTSD, drawing on 9/11 World Trade Centre data for civilians only.<sup>33</sup> The probability of detection of PTSD in primary care was approximated at 5% over the time horizon of the model, based on studies on PTSD detection rates in conventional primary care settings in England,<sup>10</sup> supported by repeated reports of lack of referral of survivors of terrorist attacks by family doctors.<sup>18 19</sup>

The probability of spontaneous remission was based on findings from a recent systematic review that 34.8% of those with PTSD following exposure to intentional trauma remit after 3 months.<sup>28</sup> However, that figure was lowered at the discretion of the authors to 20%. This was for three key reasons. First, individuals who judge they are likely to get better on their own may not engage with the programme, while those who do engage may have a more

**Table 1** Model inputs

Description	Abbreviation	Deterministic reference case	Range in one way sensitivity analysis	SE	Distribution in PSA	Reference/notes
<b>Probabilities</b>						
Prevalence of PTSD	prev_PTSD	0.310	0.30–0.40	0.01	Beta	Brewin <i>et al</i> , 2010 <sup>18</sup>
Proportion of immediate-onset PTSD	prop_immedPTSD	0.850				Andrews <i>et al</i> , 2007 <sup>30</sup>
Proportion of delayed-onset PTSD	prop_delayPTSD	0.150				Andrews <i>et al</i> , 2007 <sup>30</sup>
Average annual rate of mortality	p_death	0.00113	0.00054–0.00267	0.000001	Beta	Office for National Statistics, 2020 <sup>32</sup>
Average annual rate of mortality with PTSD	p_death_PTSD	0.00174	0.00082–0.00410	0.000001	Beta	Giesinger <i>et al</i> , 2020 <sup>33</sup> applied to ONS mortality rate <sup>32</sup>
Sensitivity of TSQ (3 months)	sens_TSQ3	0.948	0.853–0.995	0.03	Beta	Andrews <i>et al</i> , 2007 <sup>30</sup>
Specificity of TSQ (3 months)	spec_TSQ3	0.255	0.223–0.281	0.05	Beta	Brewin <i>et al</i> , 2010 <sup>31</sup>
Sensitivity of TSQ (9 months)	sens_TSQ9	0.872	0.785–0.959	0.05	Beta	Brewin <i>et al</i> , 2010 <sup>31</sup>
Specificity of TSQ (9 months)	spec_TSQ9	0.393	0.354–0.432	0.07	Beta	Brewin <i>et al</i> , 2010 <sup>31</sup>
Detection of PTSD through primary care routes	p_detectPTSD	0.050	0.045–0.055	0.01	Beta	Ehlers <i>et al</i> 2009 <sup>10</sup> ; Rubin and Wessely, 2013 <sup>22</sup>
CBT uptake	p_CBTuptake	0.875	0.788–0.963	0.3	Beta	Brewin <i>et al</i> , 2010 <sup>18</sup>
CBT completion	p_CBTcomplete	0.871	0.784–0.958	0.02	Beta	Brewin <i>et al</i> , 2010 <sup>18</sup>
Spontaneous remission	p_sponremit	0.200	0.180–0.220	0.01	Beta	Authors' assumption; Santiago <i>et al</i> , 2013 <sup>28</sup>
Recovery with CBT	p_CBTrecover	0.624	0.562–0.686	0.04	Beta	Brewin <i>et al</i> , 2010 <sup>18</sup>
Partial recovery with CBT	P_CBTpartrecover	0.136	0.122–0.150	0.04	Beta	Authors' assumption; Brewin <i>et al</i> , 2010 <sup>18</sup>
<b>Costs per annum (2018 UK prices)</b>						
PTSD	c_PTSD	1173	1056–1290	0.3	Gamma	NICE, 2018, <sup>25</sup> SD Mavrenzouli <i>et al</i> , 2020 <sup>36</sup>
Partial recovery from PTSD	c_partPTSD	642	577–706	0.3	Gamma	Authors' assumption; NICE, 2018b, SD Mavrenzouli <i>et al</i> , 2020 <sup>36</sup>
No PTSD	c_noPTSD	110	99–121	0.3	Gamma	NICE, 2018b, SD Mavrenzouli <i>et al</i> , 2020 <sup>36</sup>
Identifying and screening	c_TSQ	588	529–647	0.3	Gamma	Fuchkan, 2015, <sup>34</sup> SD Mavrenzouli <i>et al</i> , 2020 <sup>36</sup>
Clinical assessment	c_SCID	588	529–647	0.05	Gamma	Fuchkan, 2015, <sup>34</sup> SD Mavrenzouli <i>et al</i> , 2020 <sup>36</sup>

Continued





Table 1 Continued

Description	Abbreviation	Deterministic reference case	Range in one way sensitivity analysis	SE	Distribution in PSA	Reference/notes
CBT IAPT treatment	c_IAPT	1844	1660–2029	0.05	Gamma	Curtis and Burns, 2018 <sup>35</sup> ; SD Mavrenzouli et al, 2020 <sup>36</sup>
Utilities (QALYs) per annum						
PTSD	u_PTSD	0.610	0.549–0.671		Beta alpha:96.04, Lambda: 157.4	Gospodarevskaya and Segal, 2015 <sup>37</sup>
Partial recovery from PTSD	u_partPTSD	0.730	0.657–0.803	0.05	Beta	Authors' assumption; Gospodarevskaya and Segal, 2015 <sup>37</sup>
No PTSD	u_noPTSD	0.850	0.765–0.935	0.05	Beta	Gospodarevskaya and Segal, 2015 <sup>37</sup>

CBT, cognitive-behavioural therapy; IAPT, Improving Access to Psychological Therapies; NICE, National Institute for Health and Care Excellence; ONS, Office for National Statistics; PSA, Probabilistic Sensitivity Analysis; PTSD, post-traumatic stress disorder; QALY, quality-adjusted life-year; SCID, Structured Clinical Interview for DSM-5; TSQ, Trauma Screening Questionnaire.

chronic course. Second, remission is based on no longer meeting diagnostic criteria for PTSD and in practice many people may have significant residual symptoms that could benefit from treatment. For example, they may still have clinical levels of depression or have a phobic condition. Third, remission in the literature has only been measured at one point in time and people may fluctuate between meeting and not meeting diagnostic criteria if they are followed up for longer. For example, they might have another onset triggered by an inquest or court case.

The costs per person for screening and assessment, both averaging £588, were calculated using 2015 data from the London bombings inflated to 2018 prices.<sup>34</sup> These costs included start-up and management of the programme, finding, screening and assessing participants and referral management. The cost of treatment through IAPT (£1710) was calculated using unit costs of health and social care at 2018 prices (£95) multiplied by an average number of 12×1.5 hours sessions.<sup>35</sup> To be conservative, we have also assumed that a minority (10%) of service users with more severe needs would instead make use of 20 hours of specialist trauma therapy delivered by Band 8d grade clinical psychologists with overheads at a cost of £3052, increasing the average cost of treatment to £1844.<sup>35 36</sup>

The costs of medication, healthcare, and PSS were approximations based on a recent expert panel review convened in England to review the economic evidence on PTSD.<sup>17</sup> The annual costs of being in the PTSD or no PTSD health states were approximated by the panel as £1173 and £110 per person respectively at 2018 prices. Forecast costs included medication, inpatient hospital stays, outpatient visits, general practitioners and district nursing, outreach and home help, and psychological treatment. The cost of being in the partial recovery from PTSD health state was assumed to be mid-way between having PTSD and not having PTSD (£642) to capture the associated costs of subclinical symptoms. Our analysis is conservative as productivity losses arising from disrupted education or employment were excluded given the NHS and PSS perspective taken.

QALYs were used as the measurement of health gain. A preference-weight of '1' equates to perfect health, '0' to death, and negative values (worse than death) are permitted. We were unable to identify UK utility values for our study population, and instead the PTSD and no PTSD utilities, 0.610 and 0.850, respectively, were based on an Australian study in the context of sexual abuse.<sup>37</sup> The utility value for subclinical PTSD resulting from partial recovery with CBT was approximated as the midpoint between having PTSD and not having PTSD.

We also assumed that during the initial first year of the model, individuals who had delayed onset PTSD and were only identified at the second 9-month screening would have the utility and costs associated with PTSD for 6 months; and only in subsequent years, depending on treatment effect or spontaneous remission, would they gain the utilities/cost avoided associated with partial

**Table 2** Incremental cost-effectiveness ratio (ICER)

	Total costs (£)	Average costs (£)	Total effect (QALYs)	Average effect (QALYs)	ICER (95% CI) (£)
Screen-and-treat	2 770 909	2771	3805	3.804	–
Treatment-as-usual	1 732 465	1732	3674	3.674	–
Incremental difference	1 038 444	1038	131	0.131	7931 (2622 to 92 459)

QALY, quality-adjusted life-year.

PTSD or no PTSD. This is conservative, as the delay in onset of PTSD will actually have meant that for some individuals their utility values will be higher (as they spent less time with PTSD) and their costs lower than what we now assume in the model.

### Sensitivity analysis

One-way sensitivity analysis was conducted to test the robustness of the results by varying utility and probability model parameters by 10% and all costs by 20% in either direction (to reflect the potential for considerable variation).

A probabilistic sensitivity analysis with 1000 iterations was also conducted to vary input variables simultaneously. A gamma distribution was assumed for costs because the data are skewed and constrained between zero and positive infinity, and a beta distribution was assumed for probabilities and outcomes because the data are binomial and constrained between zero and one. Distribution parameters for utilities associated with PTSD and prevalence of PTSD, sensitivity and specificity of the TSQ, as well as likelihood of CBT completion and recovery after CBT were taken from previous research. For the underlying probability of mortality in the population, we assumed annual

mortality rates might range between 3-year averages in England seen at age 30 and age 50. For parameters where distributions were not available, we had to make expert assumptions on plausible SEs to estimate beta and gamma distributions around the mean. For probabilities with minimal uncertainty, we assumed a SE of 0.01, with the exception of a large error of 0.30 reflecting uncertainty in uptake of intervention. In line with previous analyses, most costs were assumed to have an SE of 0.30, with the exception of therapeutic intervention costs where the SE was 0.05 as salary costs for psychologists delivering interventions are dependent on national pay scales.

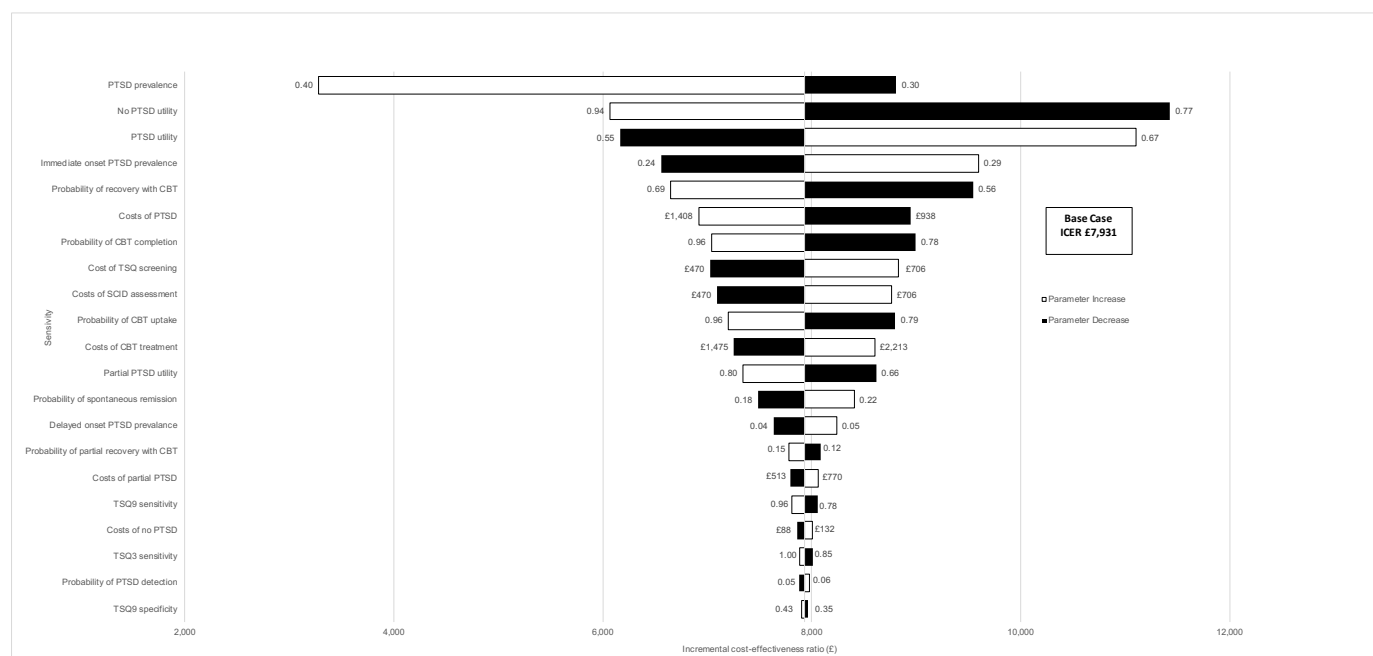
### Patient and public involvement

None.

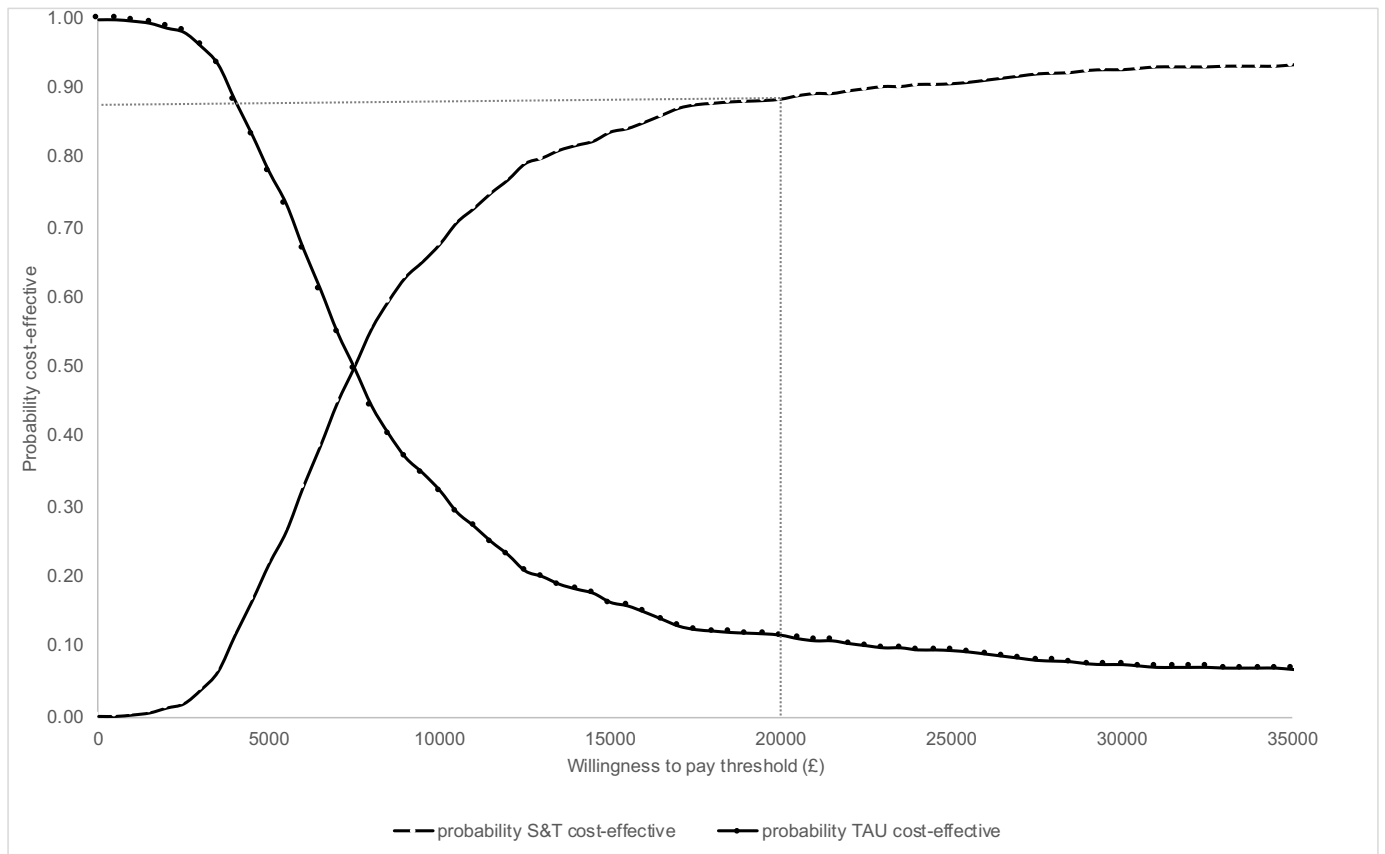
## RESULTS

### Cost-effectiveness

The total costs and effects for 1000 individuals and the average costs and effects per person are shown as accrued over the 5-year time horizon (table 2). The ICER (£7931) was expressed as the incremental cost per QALY gained compared with treatment as usual. NICE



**Figure 2** Tornado diagram. CBT, cognitive-behavioural therapy; ICER, incremental cost-effectiveness ratio; PTSD, post-traumatic stress disorder; SCID, Structured Clinical Interview for DSM-5; TSQ, Trauma Screening Questionnaire.



**Figure 3** Cost-effectiveness acceptability curve. S&T, screen-and-treat; TAU, treatment-as-usual.

in England employs guidelines that compare ICER values to a willingness-to-pay threshold of £20 000 per QALY. Given the ICER is below that threshold, a screen-and-treat approach would be considered a cost-effective option based on the model inputs.

### One-way sensitivity analysis

The sensitivity of the incremental cost-effectiveness ratio to an increase or decrease in model input variables is shown in the tornado diagram (figure 2). In short, the key drivers of the ICER were the overall prevalence of PTSD (prev\_PTSD), utility of being in the PTSD or no PTSD health states (u\_PTSD, u\_noPTSD), prevalence of immediate onset PTSD (prev\_IPTSD), the probability of recovery with CBT and the costs associated with having PTSD (c\_PTSD).

### Probabilistic sensitivity analysis

The incremental costs and benefits, having run the model over 1000 iterations, are presented as a cost-effectiveness acceptability curve (figure 3). This curve represents the proportion of iterations (out of 1000) that would be considered cost-effective at various willingness-to-pay thresholds. The screen-and-treat approach was found to have an 88% chance of being considered cost-effective given a willingness-to-pay threshold of £20 000 per QALY. The probabilistic sensitivity analysis was also used to calculate the 95% CI (£2621 to £92 459).

### DISCUSSION

The primary aim of the study was to calculate the incremental cost-effectiveness ratio of a screen-and-treat approach to identifying and treating PTSD in adults following a major incident compared with standard care. It offers important system learning for emergency response planners as the comparator group represents what would likely happen (the counterfactual) if a screen-and-treat approach is not implemented. Results show an incremental cost-effectiveness ratio of £7931 per QALY gained. This is below the willingness-to-pay threshold of £20 000 per QALY employed in NICE decision-making contexts and would therefore be seen as representing value for money. Effectively, although it costs more than treatment-as-usual, a screen-and-treat approach delivers population health outcomes that are considered to be sufficiently better to justify the higher costs. Whether this finding warrants utilisation of this approach will ultimately be determined by local decision-makers. Although not directly comparable because of the different target population, CBT for UK middle-aged adults treated for PTSD due to all causes, rather than just for major incidents, was found to be cost-effective, with a net monetary benefit per person over 3 years of £32 042.<sup>36</sup>

The economic model was designed to broadly mirror clinical practice, incorporating multiple rounds of screening and clinical assessment and changing sensitivity and specificity of the screening tools with time.





The model also incorporated heterogeneity in PTSD onset (immediate vs delayed) and recovery following CBT (full vs partial). The robustness of the results was demonstrated by addressing uncertainty through deterministic and probabilistic sensitivity analysis. One limitation, however, was the limited information available on the distribution of some model parameters, and in line with previous studies we made assumptions on standard errors for parameters to create distributions. The strict NICE perspective optimises the relevance of the paper to UK policy-makers. However, limiting the economic analysis to a health and social care perspective may mean that our estimate of cost-effectiveness is conservative. For example, indirect costs arising from disrupted employment<sup>38</sup> or impaired education<sup>39</sup> may be substantial for an individual involved in a major incident. Empirical analysis of the burden of PTSD following the London bombings found that indirect costs (mostly productivity losses) accounted for the majority (64%) of reported costs.<sup>34</sup>

Another limitation is the absence of data for the impact of PTSD on the general population. Utility values for adults were based on an Australian study of victims of non-terror-related trauma<sup>37</sup> and may not be generalisable to major incident-exposed adults in the UK. However, 0.61 is a conservative approximation for PTSD utility in adults compared with other economic analyses, which potentially reduces the capacity for QALY gains. Another Australian study used reported utility values as low as 0.54 for adults experiencing PTSD.<sup>40</sup> These lower utility values were used in a UK economic modelling study of psychological interventions in a general adult population with PTSD.<sup>36</sup> In an economic evaluation of treatment for US military personnel, the QALY value used was also lower with a mean baseline utility value for PTSD of 0.56.<sup>41</sup> Finally, the model did not factor in the burden of comorbidities, relapse, nor the differences in outcomes after traumatic events by key demographic factors. For example, PTSD comorbid with depression has been estimated to have a utility value of 0.53,<sup>37</sup> which is lower than the 0.61 assumed in the model. Additional studies are needed that evaluate cost-effectiveness of evidence-based interventions for high-risk groups.

Our results are potentially generalisable to a variety of emergencies, including the current pandemic. Certain groups such as those hospitalised for COVID-19 appear to have rates of PTSD that approximate those typical of victims of terrorist attacks,<sup>42 43</sup> and rates among frontline hospital and social care staff have also been reported to be high.<sup>44 45</sup> Cost-effectiveness calculations will inevitably be impacted by parameter changes arising from newly acquired knowledge about rates of disorder in different affected groups, and by differences in the ease of identifying and engaging various populations. Some of these changes, such as the increased availability of online screening and treatment, are likely to have the effect of reducing costs (and therefore increasing cost-effectiveness). Others, such as a high prevalence of affected people among immigrants with a limited

knowledge of the host country language, are likely to have the effect of increasing costs. Our model nevertheless provides a structure within which to assess the likely benefits—in the absence of directly observed data at this stage—of instituting screen-and-treat programmes in this different context.

With the psychological impact of terrorist attacks in recent years still evident across many parts of society, the impact of the COVID-19 pandemic is only just beginning to be appreciated. Further analysis might be needed for scenarios representing COVID-19, but in the meantime our conclusions provide some helpful implications. With both forms of major incident, sequelae involving severe psychological conditions including PTSD are inevitable features, causing extensive personal and community suffering. Addressing these conditions requires active investment, planning and delivery at all levels from policy-makers, strategic and operational health and care teams, and local communities. We hope that the analyses in this paper will go some way to drive a more positive attitude among key stakeholders to ensure that services for post-traumatic psychological conditions are funded and managed effectively.

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