Psilocybin with psychological support for treatment-resistant depression: an open-label feasibility study

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Summary

Background Psilocybin is a serotonin receptor agonist that occurs naturally in some mushroom species. Recent studies have assessed the therapeutic potential of psilocybin for various conditions, including end-of-life anxiety, obsessive-compulsive disorder, and smoking and alcohol dependence, with promising preliminary results. Here, we aimed to investigate the feasibility, safety, and efficacy of psilocybin in patients with unipolar treatment-resistant depression.

Methods In this open-label feasibility trial, 12 patients (six men, six women) with moderate-to-severe, unipolar, treatment-resistant major depression received two oral doses of psilocybin (10 mg and 25 mg, 7 days apart) in a supportive setting. There was no control group. Psychological support was provided before, during, and after each session. The primary outcome measure for feasibility was patient-reported intensity of psilocybin’s effects. Patients were monitored for adverse reactions during the dosing sessions and subsequent clinic and remote follow-up. Depressive symptoms were assessed with standard assessments from 1 week to 3 months after treatment, with the 16-item Quick Inventory of Depressive Symptoms (QIDS) serving as the primary efficacy outcome. This trial is registered with ISRCTN, number ISRCTN14426797.

Findings Psilocybin’s acute psychedelic effects typically became detectable 30–60 min after dosing, peaked 2–3 h after dosing, and subsided to negligible levels at least 6 h after dosing. Mean self-rated intensity (on a 0–1 scale) was 0.51 (SD 0.36) for the low-dose session and 0.75 (SD 0.27) for the high-dose session. Psilocybin was well tolerated by all of the patients, and no serious or unexpected adverse events occurred. The adverse reactions we noted were transient anxiety during drug onset (all patients), transient confusion or thought disorder (nine patients), mild and transient nausea (four patients), and transient headache (four patients). Relative to baseline, depressive symptoms were markedly reduced 1 week (mean QIDS difference –11.8, 95% CI –9.15 to –14.35, p=0.002, Hedges’ g=3.1) and 3 months (–9.2, 95% CI –5.69 to –12.71, p=0.003, Hedges’ g=2) after high-dose treatment. Marked and sustained improvements in anxiety and anhedonia were also noted.

Interpretation This study provides preliminary support for the safety and efficacy of psilocybin for treatment-resistant depression and motivates further trials, with more rigorous designs, to better examine the therapeutic potential of this approach.

Funding Medical Research Council.

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psychedelics within their lifetime than among those who used no psychedelics but an equivalent amount of other drugs.11 In modern trials, psychedelics have been found to reduce anxious,14,15 depressive,15,16 and obsessive-compulsive symptoms,15 as well as addictive behaviours,18,19 often for several months after just one or two exposures. Extensive historical and modern evidence now supports the view that, administered in a controlled environment with appropriate support, psychedelics have a favourable safety profile.20

Depression is a major public health problem; it is a leading contributor to the global burden of disease, affecting hundreds of millions of people worldwide, and costing the USA alone more than US$200 billion each year.21 Antidepressant medications and cognitive behavioural therapy can be effective for some patients, but around 20% do not respond to any intervention, and many of those who do respond, eventually relapse.22 We aimed to investigate the safety and feasibility of psilocybin in patients with treatment-resistant depression, and to establish an initial impression of its efficacy. We postulated that the treatment would be well tolerated and depressive symptoms would be substantially reduced from baseline at a severe degree (17+ on the 21-item Hamilton Depression Rating scale [HAM-D]), and no improvement despite two adequate courses of antidepressant treatment of different pharmacological classes lasting at least 6 weeks within the current depressive episode.23 Exclusion criteria were: current or previously diagnosed psychotic disorder; immediate family member with a diagnosed psychotic disorder; medically significant condition rendering unsuitability for the study; history of serious suicide attempts (requiring hospitalisation); history of mania; blood or needle phobia; positive pregnancy test at screening or during the study; and current drug or alcohol dependence.

Information about the study’s recruitment was sent to general practitioners via the North West London Clinical Research Network. However, patients were also allowed to self-refer to the study if they were UK residents. In every case, patients initiated contact with the research team (via email, letter, or telephone), were sent a study information sheet, and a subsequent telephone screening was arranged, during which the lead psychiatrist on the trial (MBo) obtained information about the patient’s demographics, medical and psychiatric history, and other key inclusion or exclusion criteria. The patient’s general practitioner or psychiatrist provided written documentation of the patient’s diagnosis and mental health background in every case.

This trial received a favourable opinion from the National Research Ethics Service London—West London, was sponsored and approved by Imperial College London’s Joint Research and Compliance Office (JRCO), and was adopted by the National Institute for Health Research Clinical Research Network. The National Institute for Health Research/Wellcome Trust Imperial Clinical Research Facility gave site-specific approval for the study.
The study was reviewed and approved by the Medicines and Healthcare products Regulatory Agency (MHRA). All participants provided written informed consent. Study and data monitoring was carried out independently by the Imperial Clinical Research Facility and JRCO.

**Procedures**

Psilocybin was obtained from THC-pharm (Frankfurt, Germany) and formulated into the investigational medicinal product (5 mg psilocybin in size 0 capsules) by Guy’s and St Thomas’ Hospitals’ Pharmacy Manufacturing Unit (London, UK). A Home Office Licence for storage and dispensing of Schedule One drugs was obtained.

Screening consisted of written informed consent, a thorough evaluation of the patient’s physical and mental health background, a psychiatric interview (Mini-International Neuropsychiatric Interview), clinician assessments of depression severity (the 21-item HAM-D and the Montgomery-Åsberg Depression Rating Scale [MADRS], and Global Assessment of Functioning [GAF]; all assessed by MBo), and additional patient-rated scales (16-item Quick Inventory of Depressive Symptoms [QIDS], Beck Depression Inventory [BDI—original version], Spielberger’s State-Trait Anxiety Inventory [form 2, trait version only; STAI-T], and the Snaith-Hamilton Pleasure Scale [SHAPS]). Patients also received a thorough physical health check, consisting of an electrocardiogram, routine blood tests, blood pressure, heart rate, and physical examination. At the end of screening, eligible patients were given an opportunity to meet with the two clinical psychiatrists who would support them through the remainder of the trial.

Eligible patients attended a subsequent visit involving a baseline functional MRI (fMRI) scanning session lasting 60 min, followed by an extensive preparatory session with their allocated psychiatrists; fMRI data will be reported elsewhere. This preparatory session involved inviting the patient to talk openly about their personal history (including thoughts on the origins of their depression), a discussion of psilocybin’s psychological effects, and simulation of aspects of the dosing session itself, such as listening to a sample of the session music while wearing eyeshades. The preparatory session typically lasted for 4 h, with lunch and breaks provided.

Patients enrolled in the study attended two subsequent dosing sessions that were separated by 7 days. No more than one patient was dosed on any given day. Patients arrived at the research facility (Imperial Clinical Research Facility) at 0900 h, gave a urine sample for drugs of abuse (including amphetamines, benzodiazepines, opiates, and cannabinoids), performed a breathalyser test for alcohol use, and completed interim QIDS, BDI, and STAI-T assessments to ensure no substantial deviation from baseline measures. They were then taken to a dosing room that was pre-decorated (eg, with low lighting). Patients were invited to relax on a ward bed in a supine or reclined position and music was played through high-quality stereo speakers and earphones. The two psychiatrists sat on either side of the bed. Patients were supervised at all times by at least two staff members.

Dosing commenced at 1030 h in every case. Patients received a low oral dose of psilocybin 10 mg (two 5 mg capsules) on a first dosing day and a high oral dose of psilocybin 25 mg (five 5 mg capsules) on a second dosing day, separated by 1 week. Blood pressure, heart rate, and observer ratings of the intensity of psilocybin’s acute psychoactive effects (0–4, with 0 signifying no effects and 4 signifying extreme effects) were measured at baseline (typically 5 min before dosing) and 30, 60, 120, 180, 240, 300, and 360 min after dosing. Subjective ratings of the acute altered state of consciousness using the revised

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**Figure 1:** Schedule of study interventions

![Figure 1: Schedule of study interventions](https://www.thelancet.com/psychiatry)
11 dimension altered states of consciousness questionnaire (11D ASC)\textsuperscript{a} were completed 6–7 h after dosing.

Psychiatrists adopted a non-directive, supportive approach, allowing the patient to experience a mostly uninterrupted inner "journey". Check-ins (ie, asking the patient how they are feeling) occurred at the same timepoints as the physiological recordings. Tranquilising medications (oral lorazepam and risperidone) were available if necessary. The phenomenology of the acute experience, including accounts of the nature of the therapeutic support provided before, during, and after the experience, and considerations related to the music selection and other aspects of the clinical setting, will be discussed in separate publications.

Return transport from the research facility was organised ahead of dosing sessions. Patients were taken to and from the sessions accompanied by a close friend or relative, and had the option of staying overnight in accommodation adjacent to the hospital. Emergency contact details were provided, and patients confirmed their safe return from the research facility.

Patients were contacted via telephone 1 day after their low-dose session to check on their wellbeing and monitor for any adverse events. Patients returned to the research facility 1 day after their high-dose session for a post-treatment fMRI scan lasting 60 min. After the fMRI scan, patients completed interim questionnaires (QIDS, STAI-T, and HAM-D), and were invited back to the research facility where they were met by their psychiatrists to discuss their experience the previous day.

Patients attended one further study visit to the research facility 1 week after their high-dose session, during which all baseline questionnaires and assessments were repeated and an opportunity was provided for further psychological debriefing (the 1 week follow-up visit). Assessments of HAM-D, MADRS, and GAF were again done by MBo. Subsequent assessments of clinical progress were done via email 2, 3, and 5 weeks after the high-dose session; we assessed only QIDS during subsequent follow-up, so as not to overload the patient. Final follow-up was done remotely at 3 months after the high-dose session, and included QIDS, BDI, STAI-T, and SHAPS. Patients were made aware that they could contact the study psychiatrists at any time if their depression deteriorated. Figure 1 summarises the screening, intervention, and follow-up procedures in this study.

**Outcomes**

The main objective of this study is to optimise the protocol for the administration of oral psilocybin in this patient group, while gaining an initial impression of treatment efficacy. The primary outcome measure to assess feasibility was patient-rated subjective intensity of psilocybin’s effects, which we report on a 0–1 scale. We assessed the safety of the intervention through clinical monitoring during and after dosing sessions, and during 3 months of face-to-face and remote follow-up. We also aimed to assess the preliminary efficacy of psilocybin in patients with treatment-resistant depression; the primary outcome measure for this endpoint was mean change in the severity of self-reported depressive symptoms (with the 16 item QIDS) from baseline to 1 week after the high-dose psilocybin session. The QIDS was chosen as the primary outcome measure due to its brevity, increasingly widespread use, and validity at 1 week intervals.\textsuperscript{25} We chose to assess the primary efficacy endpoint at 1 week after the high-dose session to allow comparison with previous studies of ketamine infusion for treatment-resistant depression;\textsuperscript{26} the low-dose session was conceived a priori as a safety session rather than a treatment session. We also assessed change in BDI, STAI-T, and SHAPS between baseline and 1 week and 3 months of follow-up, and change in HAM-D, MADRS, and GAF between baseline and 1 week of follow-up.

**Statistical analysis**

In this feasibility study, we did not perform a formal power calculation. We planned to recruit 12 patients to provide an initial impression of the tolerability and efficacy of this novel treatment approach. A subsequent protocol amendment (Oct 6, 2015) increased the recruitment to 20 patients to provide statistical power for fMRI imaging. Here, we report findings for the 12 patients initially enrolled; outcome and fMRI data for all 20 patients will be reported separately.

Due to the small population, two-tailed Wilcoxon signed ranks tests were performed for non-parametric data. Two-tailed \( t \) tests were also performed and the relevant \( t \) values are provided in the appendix. We provide 95% CIs around the mean differences. We calculated

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1. See Online for appendix.
2. 38 telephone screened
3. 18 attended screening visit
4. 12 recruited to the study and fully compliant with protocol
5. 20 excluded because they did not meet the entry criteria
6. 6 excluded because of insufficiently severe depression (HAM-D)
7. 34 excluded because they did not meet the entry criteria

Figure 2: Trial profile

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effect sizes using the Hedges’ g formula, which is more appropriate for small sample sizes. Hedges’ g values are very similar to Cohen’s d values for dependent data.

This trial is registered with the ISRCTN registry, number ISRCTN14426797. The registration was initiated on March 30, 2015, and finalised on July 7, 2015 (delay caused by administrative issues); recruitment started on April 21, 2015, after initiation of public registration.

Role of the funding source
The study funder had no role in the design, data collection, analysis, interpretation, or writing of the report. The corresponding author had full access to all of the data in the study and had final responsibility for the decision to submit for publication.

Results
Enrolment started on May 1, 2015, and finished on Aug 25, 2015. 72 people were initially considered for the study, most of whom self-referred after hearing about this trial through public outreach work (eg, public presentations by the investigators and media reports). 38 were considered appropriate for a telephone screen, from which 18 were invited for a formal screening visit, and 12 were ultimately recruited for the trial (figure 2), of whom ten were self-referrals. Patients’ demographic and clinical characteristics are shown in table 1. Nine of the 12 patients met criteria for severe or very severe depression at baseline (BDI score ≥30), with the remaining three patients meeting criteria for moderate depression (BDI score 19 to <30). 11 patients had received some form of psychotherapy before participation in the study.

The acute effects of psilocybin were well tolerated by all of the patients and no serious or unexpected adverse events occurred. Mean self-rated intensity of psilocybin experience was 0.51 (SD 0.36) for the low-dose session and 0.75 (0.27) for the high-dose session (difference 0.24 [95% CI 0.06–0.41], Z=2.4, p=0.019).

Table 1: Baseline and demographic characteristics, by patient

| Sex | Age, years | Ethnic origin | Employment status | Estimated illness duration, years | Baseline scores | Past unsuccessful medications | Past psychotherapy | Education | Weekly alcohol intake, units | Previous psilocybin use (time since last use) |
|-----|------------|---------------|------------------|----------------------------------|-----------------|------------------------------|-------------------|----------|-----------------------------|---------------------------------------------|
| 1   | Female     | 43            | Black Caribbean  | Employed                         | 30              | 36                           | 19                | 72       | None                        | Postgraduate                                |
| 2   | Male       | 40            | Hispanic         | Unemployed                       | 25              | 33                           | 28                | 76       | SSRI (two), SNRI, NDRI, NSSRI, MAOI | Cognitive narrative therapy                  |
| 3   | Male       | 37            | White            | Employed                         | 17              | 22                           | 18                | 63       | SSRI (two), SNRI            | Cognitive behavioural therapy, group therapy |
| 4   | Female     | 30            | White            | Studying                         | 10              | 26                           | 18                | 67       | NDRI, NSSRI                 | Cognitive behavioural therapy               |
| 5   | Male       | 34            | White            | Unemployed                       | 12              | 38                           | 25                | 71       | SSRI (three), TCA           | Cognitive and mindfulness behavioural therapy |
| 6   | Female     | 57            | White            | Unemployed                       | 29              | 39                           | 23                | 78       | SSRI (four), SNRI, SARI    | Counselling                                  |
| 7   | Male       | 52            | White            | Unemployed                       | 27              | 33                           | 22                | 57       | TCA, SARI                   | Counselling, mindfulness                     |
| 8   | Female     | 37            | White            | Employed                         | 17              | 39                           | 17                | 71       | SSRI (two), TCA             | Counselling                                  |
| 9   | Male       | 37            | White            | Unemployed                       | 15              | 32                           | 26                | 71       | SSRI (three), SNRI         | Counselling, cognitive behavioural therapy   |
| 10  | Female     | 36            | Black Caribbean  | Unemployed                       | 8               | 47                           | 28                | 75       | SSRI (two), NSSRI          | Counselling                                  |
| 11  | Female     | 64            | White            | Employed                         | 15              | 24                           | 17                | 72       | SSRI (four), SNRI, NDRI, MAOI, Na+ channel blocker, SARI, DRI | Cognitive behavioural therapy               |
| 12  | Male       | 45            | White            | Employed                         | 8               | 35                           | 17                | 68       | SSRI, TCA                   | Cognitive behavioural therapy               |

BDI=Beck Depression Inventory. HAMD-D=Hamilton Depression Rating scale. STAI-T=State-Trait Anxiety Inventory. SSRI=selective serotonin-reuptake inhibitor. SNRI=serotonin–noradrenaline reuptake inhibitor. NDBI=noradrenaline-dopamine-reuptake inhibitor. NDRI=noradrenaline and specific serotonin-reuptake inhibitor. MAOI=monoamine oxidase inhibitor. TCA=tricyclic antidepressant. SARI=serotonin antagonist and reuptake inhibitor. DRI=dopamine-reuptake inhibitor. *One medication from each class, unless otherwise stated.
No patients required tranquilising medications (oral lorazepam and risperidone) during the dosing sessions. Psilocybin's acute psychedelic effects typically became detectable between 30 min and 60 min after dosing, peaked between 2 h and 3 h after dosing, and subsided to negligible levels at which the patient could be assessed for discharge at least 6 h after dosing (appendix). Self-rated experiences on the 11D-ASC questionnaire from the two sessions are shown in the appendix. Results from interim patient questionnaires (QIDS, BDI, and STAI-T), done immediately before the low-dose session to monitor for substantial changes since enrolment, did not differ from baseline (data not shown). Interim questionnaires done the day after the high-dose session showed some reduction in depressive symptoms (data for HAM-D in appendix; data for QIDS and STAI-T not shown).

Table 2: Adverse events by patient

| Severity        | Timing or onset                           | Duration              |
|-----------------|------------------------------------------|-----------------------|
| Patient 1       |                                           |                       |
| Transient anxiety | Mild                                     | Onset of both sessions | 60 min                |
| Transient headache | Mild                                     | Day after high-dose session | One day only         |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-120 min            |
| Patient 2       |                                           |                       |
| Transient anxiety | Mild                                     | Anticipatory anxiety only (both sessions) | 30 min               |
| Patient 3       |                                           |                       |
| Transient anxiety | Mild                                     | Anticipatory anxiety only (both sessions) | 30 min               |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-180 min            |
| Patient 4       |                                           |                       |
| Transient anxiety | Mild (low dose), moderate (high dose)    | Onset of both sessions and peak of high dose | 60 min (low dose), 120 min (high dose) |
| Transient nausea | Moderate                                  | Onset phase of high-dose session | Arose and subsided within 60 min |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-180 min            |
| Transient paranoia | Mild                                     | Peak of high-dose session | Arose and subsided within 30 min |
| Patient 5       |                                           |                       |
| Transient anxiety | Moderate (low dose), severe (high dose)  | Onset of both sessions and peak of high dose | 60 min (low dose), 150 min (high dose) |
| Transient headache | Mild                                     | Day after high-dose session | One day only         |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-120 min            |
| Patient 6       |                                           |                       |
| Transient anxiety | Mild                                     | Anticipatory anxiety only (both sessions) | 30 min               |
| Patient 7       |                                           |                       |
| Transient anxiety | Mild                                     | Anticipatory anxiety only (both sessions) | 30 min               |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-180 min            |
| Patient 8       |                                           |                       |
| Transient anxiety | Mild or negligible                        | Anticipatory anxiety only (both sessions) | 30 min               |
| Patient 9       |                                           |                       |
| Transient anxiety | Mild (low dose), moderate (high dose)    | Onset of low-dose and high-dose session | 60 min (low dose), 150 min (high dose) |
| Transient headache | Mild                                     | Day after high-dose session | One day only         |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-180 min            |
| Patient 10      |                                           |                       |
| Transient anxiety | Mild                                     | Onset of both sessions | 60 min                |
| Transient nausea | Mild                                     | Onset and peak of low-dose session | Subsided after 90 min |
| Transient headache | Mild or moderate                         | Day after high-dose session | 2 days               |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-180 min            |
| Patient 11      |                                           |                       |
| Transient anxiety | Moderate (both sessions)                  | Onset phase and peak of both sessions | 150 min (both sessions) |
| Transient nausea | Mild (high dose)                          | Onset phase of high-dose session | Arose and subsided within 60 min |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-180 min            |
| Transient paranoia | Mild                                     | Peak of low-dose session | Arose and subsided within 60 min |
| Patient 12      |                                           |                       |
| Transient anxiety | Mild                                     | Anticipatory anxiety only (both sessions) | 30 min               |
| Transient confusion | Mild (core drug effect)                   | Peak of both sessions  | 60-180 min            |
The most common adverse events were transient anxiety (mostly mild) during drug onset (n=12), transient confusion or thought disorder (n=9), mild and transient nausea (n=4), and transient headache (n=4; table 2). These adverse events were expected psychological effects of psilocybin. Subacute headache typically presented 1 day after the psilocybin session, and subsided after 1–2 days. Paranoia presented in only one patient, but this was mild and transient. No prolonged psychotic symptoms were observed in any of the patients. One patient contacted the study psychiatrists during the 3 months of follow-up due to deterioration of their depression, and was referred to their general practitioner.

QIDS depression scores were significantly reduced from baseline to 1 week and 3 months post-treatment, with the maximum effect at 2 weeks (figure 3, table 3). BDI and clinician-administered ratings confirmed these results (figure 4, table 3). All patients showed some reduction in depression severity at 1 week that was sustained in the majority for 3 months (appendix). According to standard criteria for determining remission (eg, a score of ≤9 on the BDI), eight (67%) of the 12 patients achieved complete remission at 1 week and seven patients (58%) continued to meet criteria for response (50% reduction in BDI score relative to baseline) at 3 months, with five of these (42%) still in complete remission (figure 4, table 3). STAI-T anxiety scores were also significantly reduced at 1 week and 3 months post-treatment, as were SHAPS anhedonia scores for 1 week and 3 months post-treatment (table 3).

**Discussion**

In this open-label, single-arm pilot study, we sought to examine the feasibility of administering psilocybin to patients with treatment-resistant depression as a prelude to a larger randomised controlled trial. Our results support...
Because this was a small-scale feasibility study with an open-label design, strong inferences cannot be made about the treatment’s therapeutic efficacy. However, the data do suggest that further research is warranted. The response rate to psilocybin was 67% (n=8) at 1 week after treatment (HAM-D and BDI), and seven of these eight patients also met criteria for remission. Moreover, 58% (n=7) of the patients maintained their response for 3 months, and 42% (n=5) remained in remission. It is also worth noting that psilocybin has a favourable toxicity profile and is not associated with compulsive drug-seeking behaviours in animals or human beings. The side-effects that we noted were minor, and expected in light of previous studies of psilocybin.

Spontaneous recovery in refractory depression is rare, and many of the patients in the present study reported having depression for much of their adult lives (mean estimated illness duration 17·8 years [SD 8]). Key questions for future research therefore should address why the antidepressant effect observed in the present study is so large, and if it can be replicated when tighter experimental controls are introduced. Because the treatment in our study consisted of not just two psilocybin administrations but also psychological support before, during, and after these sessions, as well as a positive therapeutic environment for the sessions, the relative effects of these factors need to be determined, which can only be done by conducting further trials with appropriate control conditions.

A logical next step would be to carry out a placebo-controlled randomised trial in which the level of therapist contact is consistent between conditions. This would enable any between-group differences in clinical outcomes to be attributed to psilocybin rather than the psychological support provided. However, a positive interaction between these variables seems likely, and inert placebo-based blinds are known to be ineffective in studies involving conspicuous experimental interventions, because patients can easily discern whether they are in the active condition or not. Use of an active placebo for the control condition might therefore be worth considering. Additionally, randomised comparative efficacy trials (eg, with an optional crossover component) incorporating another treatment for refractory depression (eg, ketamine infusion) could also be explored.

The magnitude and persistence of the antidepressant effects observed here are not incongruent with what has been observed previously with psilocybin in chronic psychiatric conditions. For example, 80% of long-term heavy tobacco smokers demonstrated abstinence from smoking 6 months after two treatment sessions with psilocybin. Alcohol-dependent patients demonstrated significantly reduced drinking behaviours over 8 months after one or two psilocybin sessions. Significantly decreased anxiety and depression scores were observed 3 and 6 months after a single dose of psilocybin in patients with anxiety related to end-stage cancer, and improvements in wellbeing lasting for more than 1 year were observed in healthy individuals given a single dose of psilocybin. Rapid and enduring decreases in depressive symptoms were also recently found in a small-scale feasibility trial involving the psychedelic brew, ayahuasca.

It is important to consider the limitations of this pilot study; for example, although all patients showed some clinical improvements for at least 3 weeks after treatment, and no serious or unexpected adverse reactions were observed, enduring improvements beyond 3 weeks were not observed universally, and five of the 12 patients showed a degree of relapse at 3 months.

One should be cautious of the potential for inflated effect sizes in early trials, particularly when the sample size is small. That all patients showed some improvement in their depressive symptoms for up to 3 weeks after treatment could be suggestive of an expectancy bias. It may also be relevant that most patients in this trial were self-referring and, thus, actively sought this treatment. Psychedelics are known to promote suggestibility, which might have further enhanced positive outcomes. Future double-blind randomised controlled trials could address the role of expectancy and suggestibility by measuring and controlling these variables. For example, patients could be asked about their pre-treatment expectations, suggestions could be controlled between conditions, and outcomes from self-referred patients could be compared with those from patients referred via clinicians. From a more pragmatic perspective, if expectancy or suggestibility are found to be influential in the context of psychedelic therapy, they could be treated as exploitable components of the treatment model rather than confounding variables.
Serotonergic antidepressants have been found to down-regulate the primary receptor target of psilocybin (the 5-HT2A receptor) and attenuated subjective responses to psychedelics have previously been reported in individuals chronically medicated with serotonergic antidepressants. Thus, patients may be required to withdraw from concurrent antidepressant medication before receiving psilocybin and this should only ever be done with care.

In conclusion, we sought to assess the safety and tolerability of psilocybin plus psychological support in patients with unipolar treatment-resistant depression. Our findings support the feasibility of this approach and the magnitude and duration of the post-treatment reductions in symptom severity motivate further controlled research. Psilocybin has a novel pharmacological action in comparison with currently available treatments for depression (ie, 5-HT2A receptor agonism) and thus could constitute a useful addition to available therapies for the treatment of depression.

Contributors
RCL-H and DJN designed the study and RCL-H wrote the report. RLC coordinated the study, and collected and analysed the data. MBo was the lead psychiatrist on the trial. MBh, JR, CMJD, DE, and MBi provided psychological support for the patients. All authors critically revised the report or contributed important intellectual content.

Declaration of interests
DT has received research funding and lecture honoraria from Servier, and lecture honoraria from Lundbeck. The other authors declare no competing interests.

Acknowledgments
This study was funded by an MRC clinical development scheme grant (MR/J00460X/1). MK was supported by the Beckley Foundation and this work was carried out as part of the Beckley/Imperial Research Collaboration. The research was carried out at the NIHR/Wellcome Trust Imperial Clinical Research Facility. We would like to thank Robert Sullivan (Meridian West London, London, UK) for provision of high-quality audio equipment for the dosing sessions.

References
1 Hofmann A, Frey A, Ott H, Petz Zilka T, Troxler F. Elucidation of the structure and the synthesis of psilocybin. Experientia 1958; 14: 397–99.
2 Hofmann A, Heim R, Brack A, Kobel H. Psilocybin, a psychotrophic substance from the Mexican mushroom Psilocybe mexicana Heim. Experientia 1958; 14: 107–09.
3 Halberstadt AL, Geyer MA. Multiple receptors contribute to the behavioral effects of indoleamine hallucinogens. Neuropharmacology 2011; 61: 364–81.
4 Boulougouris V, Glennen JC, Robbins TW. Dissociable effects of selective 5-HT1A and 5-HT2A receptor antagonists on serial spatial reversal learning in rats. Neuropharmacology 2008; 33: 2007–19.
5 Harvey RA. Role of the serotonin 5-HT1A receptor in learning. Learn Mem 2003; 10: 355–62.
6 Vaidya VA, Marek GJ, Aghajanian GK, Duman RS. 5-HT2A receptor-mediated regulation of brain-derived neurotrophic factor mRNA in the hippocampus and the neocortex. J Neurosci 1997; 17 (8): 2785–95.
7 Buchhorn T, Schroder H, Hollt V, Grecksch G. Repeated lysergic acid diethylamide in an animal model of depression: normalisation of learning behaviour and hippocampal serotonin 5-HT, signalling. J Psychopharmacol 2014; 28: 545–52.