

**Talimogene laherparepvec**

**Summary Notification Information Format for the Release of Genetically  
Modified Organisms Other Than Higher Plants in Accordance With  
Article 11 of Directive 2001/18/EC**

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**A. GENERAL INFORMATION**

**1. Details of notification**

- (a) **Member State of notification** Spain
- (b) **Notification number** B/ES/15/07
- (c) **Date of acknowledgement of notification** 21/07/2015
- (d) **Title of the project** A Phase 1, Multicenter, Open-label Trial to Evaluate the Safety of Talimogene Laherparepvec Injected into Liver Tumors (20140318)
- (e) **Proposed period of release** From 12/10/2015 until 29/09/2017

**2. Notifier**

Name of institution or company Amgen Limited, UK, on behalf of Amgen Inc. (study sponsor)

**3. GMO characterisation**

**(a) Indicate whether the GMO is a:**

- viroid (.)
- RNA virus (.)
- DNA virus (X)
- bacterium (.)
- animal
- mammals (.)
- insect (.)
- fish (.)
- other animal (.) specify phylum, class
- other, specify (kingdom, phylum and class)

**(b) Identity of the GMO (genus and species)**

Genus: Simplexvirus

Species: Talimogene laherparepvec is a recombinant of a wild-type Herpes simplex virus 1 (HSV-1) strain JS1, with genes ICP34.5 and ICP47 deleted and hGM-CSF inserted

**(c) Genetic stability – according to Annex IIIa, II, A(10)**

In general, DNA viruses have greater genetic stability than RNA viruses. Firstly, DNA is more thermodynamically stable than RNA; secondly, replication of DNA is a much less

error-prone process than the replication of RNA; and thirdly, more mechanisms exist in the host cell for repairing errors in DNA than in RNA.

The overall mutation rate for HSV-1 is low and has been estimated to be  $1.8 \times 10^{-8}$  mutations per nucleotide, per genomic replication (Duffy et al., 2008).

However, homologous genomic recombination may occur spontaneously in nature between the viral genomes of HSV-1 strains. For this to occur, it would be essential for a (human) cell to be infected simultaneously by two different strains.

**4. Is the same GMO release planned elsewhere in the Community (in conformity with Article 6(1)), by the same notifier?**

Yes (X) No (.)

If yes, insert the country code(s): FR (contained use)

**5. Has the same GMO been notified for release elsewhere in the Community by the same notifier?**

Yes (X) No (.)

If yes:

- Member State of notification BE, DE, GR, HU, NL, PL, SE (Contained use: AT, FR, IT, GB)
- Notification number Pending confirmation

**Please use the following country codes:**

*Austria AT; Belgium BE; Germany DE; Denmark DK; Spain ES; Finland FI; France FR; United Kingdom GB; Greece GR; Ireland IE; Iceland IS; Italy IT; Luxembourg LU; Netherlands NL; Norway NO; Portugal PT; Sweden SE*

**6. Has the same GMO been notified for release or placing on the market outside the Community by the same or other notifier?**

Yes (X) No (.)

If yes:

- Member State of notification United States of America
- Notification number IND 12412 / BLA 125518
- Member State of notification Canada
- Notification number EAU-741
- Member State of notification South Africa
- Notification number 39.4 (2/11/314-5)
- Member State of notification Switzerland
- Notification number Pending Confirmation

**7. Summary of the potential environmental impact of the release of the GMOs.**

Wild-type HSV-1 is a human pathogen which is not known to be involved in environmental processes. It does not respire and does not contribute to primary production or decomposition processes. In its virion form, it does not display any metabolic activity. There are no known indigenous vectors of HSV-1, other than human beings. The presence of natural mobile genetic elements such as proviruses, transposons or plasmids related to HSV-1 has not been reported. The genetic modifications made to produce talimogene laherparepvec do not affect its impact on the environment.

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**B. INFORMATION RELATING TO THE RECIPIENT OR PARENTAL ORGANISM  
FROM WHICH THE GMO IS DERIVED**

**1. Recipient or parental organism characterisation:**

(select one only)

viroid (.)

RNA virus (.)

DNA virus (X)

bacterium (.)

fungus (.)

animal (.)

- mammals (.)

- insect (.)

- fish (.)

- other animal (.)

(specify phylum, class)

Other, specify

**2. Name**

(i) order and/or higher taxon (for animals) Herpesvirales

(ii) genus Simplexvirus

(iii) species Herpes simplex virus 1 (HSV-1)

(iv) subspecies

(v) strain JS1 (ECACC Accession Number  
01010209)

(vi) pathovar (biotype, ecotype, race, etc.)

(vii) common name HSV-1

**3. Geographical distribution of the organism**

**(a) Indigenous to, or otherwise established in, the country where the notification is made:**

Yes (X) No (.) Not known (.)

**(b) Indigenous to, or otherwise established in, other EC countries:**

(i) Yes (X)

If yes, indicate the type of ecosystem in which it is found:

- Atlantic (X)
- Mediterranean (X)
- Boreal (X)
- Alpine (X)
- Continental (X)
- Macaronesian (X)

(ii) No (.)

(iii) Not Known (.)

**(c) Is it frequently used in the country where the notification is made?**

Yes (.) No (X)

**(d) Is it frequently kept in the country where the notification is made?**

Yes (.) No (X)

**4. Natural habitat of the organism**

**(a) If the organism is a microorganism**

water (.)

soil, free-living (.)

soil in association with plant-root systems (.)

in association with plant leaf/stem systems (.)

other, specify

Wild-type HSV-1 is an obligate pathogen of humans; other species (such as rabbits and rodents) may only be infected experimentally.

**(b) If the organism is an animal: natural habitat or usual agroecosystem:**

Not applicable.

**5. (a) Detection techniques**

The diagnosis of HSV-1 infection is usually made by the appearance of the lesions and the patient's history. However, if the clinical pattern of the lesions is not specific to HSV, its diagnosis can be made by viral culture, Polymerase Chain Reaction (PCR), viral antigen detection, Tzanck test or serology.

**5. (b) Identification techniques**

See section 5(a). PCR is the most sensitive method in the identification of HSV-1 (99% specific for HSV-1; Whitley et al, 1998).

**6. Is the recipient organism classified under existing Community rules relating to the protection of human health and/or the environment?**

Yes  No

If yes, specify:

Wild-type Herpes Simplex virus Type 1 is classified in Risk Group 2 in the European Union (EU) according to Directive 2000/54/EC on the protection of workers from risks related to exposure to biological agents at work. A Risk Group 2 biological agent is defined in the EU as 'one that can cause human disease and might be a hazard to workers; it is unlikely to spread to the community; there is usually effective prophylaxis or treatment available'.

**7. Is the recipient organism significantly pathogenic or harmful in any other way (including its extracellular products), either living or dead?**

Yes  No  Not known

If yes:

**(a) to which of the following organisms:**

humans   
animals   
plants   
other

**(b) give the relevant information specified under Annex III A, point II. (A)(11)(d) of Directive 2001/18/EC**

Humans are the only natural host for wild-type HSV-1 infection. Non-human infection is rare, but HSV-1 infection has been reported in a variety of species including rodents, rabbits, hedgehogs, and non-human primates. In the available case reports, the infection occurred subsequent to close contact with humans actively shedding virus.

The mode of transmission of wild type HSV-1 is through direct contact with infected secretions or mucous membranes/skin with lesions from an asymptomatic or symptomatic patient shedding the virus (Jerome & Morrow 2007, Chayavichitsilp 2009, Whitley 2006). Transmission of HSV-1 can also occur by respiratory droplets (Whitley 2006).

The incubation period for orolabial HSV-1 infection is 2 to 12 days, with an average of 4 days (Miller & Dummer 2007).

During one study of orolabial HSV-1 infection, the median duration of HSV-1 shedding was 60 hours when measured by polymerase chain reaction (PCR) and 48 hours when measured by viral culture. Peak viral DNA load occurred at 48 hours, with no virus detected beyond 96 hours of onset of symptoms (Boivin et al 2006).

HSV-1 also travels to the sensory ganglia, where latency is established. Oral HSV-1 infections reactivate from the trigeminal sensory ganglia, affecting the facial, oral, labial, oropharyngeal, and ocular mucosa (Usatine & Tinitigan, 2010).

Recurrent infections may be precipitated by various stimuli, such as stress, fever, exposure to sunlight, extremes in temperature, ultra-violet radiation, immunosuppression, or trauma. The virus remains dormant for a variable amount of time. On reactivation, generally the duration of symptoms is shorter and the symptoms are less severe (Usatine & Tinitigan, 2010).

The following wild type HSV-1 mediated conditions may occur: herpes labialis/cold sores; herpetic whitlow; Infections of the eye; encephalitis; genital herpes.

Neonatal HSV infection causes significant morbidity and mortality despite significant advances in treatment (reviewed in Kimberlin, 2004; Thompson & Whitley, 2011). The current estimated rate of occurrence of neonatal HSV disease in the United States is approximately 1 in 3,200 deliveries. HSV infections in newborns can be classified into three patterns, which occur with roughly equal frequency. These comprise disseminated disease involving multiple visceral organs, including lungs, liver, adrenal glands, skin, eyes, and the brain; central nervous system (CNS) disease, with or without skin lesions; and disease limited to the skin, eyes, and/or mouth (SEM disease). Patients with disseminated disease and SEM disease present earliest, generally at 10–12 days of life, whereas CNS disease presents during the second or third week of life. Since the advent of antiviral therapy the prognosis of neonatal HSV has improved. Prior to antiviral therapy, 85% of patients with disseminated HSV disease and 50% of patients with CNS



disease died within 1 year. With the use of high-dose acyclovir, 12-month mortality has reduced to 29% for disseminated neonatal HSV disease and to 4% for CNS HSV disease (reviewed in Kimberlin, 2004; Thompson & Whitley, 2011). The majority of neonatal HSV infections are caused by HSV-2, but approximately 15 to 30 percent are thought to be caused by HSV-1 Neonatal Herpes Simplex Virus Infections (Rudnick & Hoekzema 2002).

In the immunocompromised host, including those with HIV infection, HSV disease can be particularly severe, resulting in chronic, persistent, active infection and in some cases, life-threatening disease (Stewart et al, 1995). Immunosuppressed patients, especially those with impaired T-cell immunity, develop severe lesions that persist longer than those in the normal host; these lesions can progress to visceral disease. As a result of this, almost all examples of serious complications of wild-type HSV infections in humans occur in immunocompromised individuals. In these cases, the immune system fails to control the infection, and it becomes disseminated. Susceptible immunocompromised individuals include patients receiving cytotoxic therapy, transplant recipients, and patients with human immunodeficiency virus (HIV) (reviewed in Brady & Bernstein, 2004). The emergence of HSV resistance to acyclovir, a phenomenon which is mainly observed among immunocompromised patients due to the long-term treatment they receive, is also a concern. However, no case of encephalitis due to an acyclovir-resistant HSV strain has been reported to date (Rozenberg et al., 2011).

## **8. Information concerning reproduction**

### **(a) Generation time in natural ecosystems:**

HSV-1 does not persist in natural ecosystems, relying on its host organism for asexual replication with a short reproductive cycle (~18 hr.).

### **(b) Generation time in the ecosystem where the release will take place:**

Replication outside the host organism (human) does not occur and it is not known to infect species other than human under natural circumstances.

### **(c) Way of reproduction:**

Sexual (.) Asexual (X)

### **(d) Factors affecting reproduction:**

See section 8(a).

## 9. Survivability

### (a) ability to form structures enhancing survival or dormancy:

- |        |                        |                |
|--------|------------------------|----------------|
| (i)    | endospores             | (.)            |
| (ii)   | cysts                  | (.)            |
| (iii)  | sclerotia              | (.)            |
| (iv)   | asexual spores (fungi) | (.)            |
| (v)    | sexual spores (fungi)  | (.)            |
| (vi)   | eggs                   | (.)            |
| (vii)  | pupae                  | (.)            |
| (viii) | larvae                 | (.)            |
| (ix)   | Other, specify         | Not applicable |

### (b) relevant factors affecting survivability:

Wild-type HSV-1 survives in the environment as a persistent infection in the host species (humans) or as a latent infection in the nucleus of some infected cells (principally neurons of the trigeminal ganglion), where it may remain inactive indefinitely, or be reactivated giving rise to secretion of virus and sometimes (though not always) clinical symptoms.

Outside of the host, HSV-1 is an enveloped virus which is sensitive to and rapidly inactivated by both physical inactivation (dehydration, heat, low pH) and disinfectants (lipid solvents and mild detergents). It does not form survival structures and its survival outside the host organism is limited to short periods of time (Chayavichitsilp et al, 2009).

## 10. (a) Ways of dissemination

The mode of transmission of wild-type HSV-1 is through direct contact with infected secretions or mucous membranes/skin with lesions from an asymptomatic or symptomatic patient shedding the virus (Jerome & Morrow 2007, Chayavichitsilp 2009, Whitley 2006). Transmission of HSV-1 can also occur by respiratory droplets (Whitley 2006).

## 10. (b) Factors affecting dissemination

See section 10(a).

## 11. Previous genetic modifications of the recipient or parental organism already notified for release in the country where the notification is made (give notification numbers)

The parental strain of HSV-1 used in the construction of talimogene laherparepvec was named JS1. This strain was a new isolate taken from a healthy individual and

subsequently banked (ECACC Accession Number 01010209). There are no known previous genetic modifications of this strain of HSV-1.

## **C. INFORMATION RELATING TO THE GENETIC MODIFICATION**

### **1. Type of the genetic modification**

- (i) insertion of genetic material  (X)
- (ii) deletion of genetic material  (X)
- (iii) base substitution  (.)
- (iv) cell fusion  (.)
- (v) Others, specify  (.)

### **2. Intended outcome of the genetic modification**

The intended outcome of the modification is to functionally delete both copies of ICP34.5 and the ICP47 gene from the viral backbone of wild-type HSV-1 (strain JS1) and to insert an expression cassette encoding the human granulocyte macrophage colony-stimulating factor (hGM-CSF) gene in both ICP34.5 regions. The intended therapeutic strategy is to produce a direct oncolytic effect by replication of the virus within the tumour, and induction of an anti-tumour immune response, enhanced by the local expression of hGM-CSF.

### **3. (a) Has a vector been used in the process of modification?**

Yes  (.) No  (X)

There is no mobile genetic vector in talimogene laherparepvec. Shuttle vectors (plasmids) were used to construct the recombinant virus which was subsequently plaque purified.

If no, go straight to question 5.

### **3. (b) If yes, is the vector wholly or partially present in the modified organism?**

Yes  (.) No  (.)

If no, go straight to question 5.

If the answer to 3(b) is yes, supply the following information

**4. (a) Type of vector**

- plasmid (.)
- bacteriophage (.)
- virus (.)
- cosmid (.)
- transposable element (.)
- other, specify

**(b) Identity of the vector**

**(c) Host range of the vector**

**(d) Presence in the vector of sequences giving a selectable or identifiable phenotype**

- Yes (.) No (.)
- antibiotic resistance (.)
  - other, specify

Indication of which antibiotic resistance gene is inserted

**(e) Constituent fragments of the vector**

**(f) Method for introducing the vector into the recipient organism**

- (i) transformation (.)
- (ii) electroporation (.)
- (iii) macroinjection (.)
- (iv) microinjection (.)
- (v) infection (.)
- (vi) other, specify

**5. If the answer to question B.3(a) and (b) is no, what was the method used in the process of modification?**

- (i) transformation (.)
- (ii) microinjection (.)
- (iii) microencapsulation (.)
- (iv) macroinjection (.)
- (v) other, specify Homologous recombination

## 6. Composition of the insert

### (a) Composition of the insert

The hGM-CSF expression cassette contains a human cytomegalovirus immediate-early (hCMV IE) promoter, hGM-CSF gene and bovine growth hormone polyadenylation (bGH polyA) signal.

### (b) Source of each constituent part of the insert

The hCMV IE promoter sequence was derived from pcDNA3, a commercial plasmid from Invitrogen.

An IMAGE clone of the hGM-CSF gene was obtained from the Human Genome Mapping Project (HGMP) Resource Centre, UK.

The bGH polyA signal was derived from pcDNA3, a commercial plasmid from Invitrogen.

### (c) Intended function of each constituent part of the insert in the GMO

The hCMV promoter is used to drive expression of hGM-CSF gene.

hGM-CSF augments the immune response to released tumour antigens by aiding the differentiation and proliferation of dendritic cell precursors in and around the injected tumour.

The bGH polyA signal facilitates hGM-CSF mRNA transport and stability.

### (d) Location of the insert in the host organism

- on a free plasmid           (.)
- microinjection           (.)
- other, specify           Integrated in the HSV-1 genome

### (e) Does the insert contain parts whose product or function are not known?

Yes   (.)   No   (X)

If yes, specify

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**D. INFORMATION ON THE ORGANISM(S) FROM WHICH THE INSERT IS DERIVED**

The following information relates to the organism from which the inserted gene (hGM-CSF) is derived.

**1. Type of the genetic modification**

- viroid (.)
- RNA virus (.)
- DNA virus (.)
- bacterium (.)
- fungus (.)
- animal (.)
  - mammals (X) Humans
  - insect (.)
  - fish (.)
  - other animal (.)  
(specify phylum, class)

Other, specify

**2. Complete name**

- (i) order and/or higher taxon (for animals) Primate
- (ii) family name for plants
- (iii) genus Homo
- (iv) species Homo Sapiens
- (v) subspecies Homo Sapiens Sapiens
- (vi) strain
- (vii) cultivar/breeding line
- (viii) pathovar
- (ix) common name Humans

**3. Is the organism significantly pathogenic or harmful in any other way (including its extracellular products), either living or dead?**

Yes (.) No (X) Not known (.)

If yes, specify the following:

**(a) to which of the following organisms: Not Applicable**

humans (.)

animals (.)

plants (.)

others (.)

**(b) are the donated sequences involved in any way to the pathogenic or harmful properties of the organism**

Yes (.) No (X) Not known (.)

If yes, give the relevant information under Annex III A, point II(A)(11)(d):

**4. Is the donor organism classified under existing Community rules relating to the protection of human health and the environment, such as Directive 90/679/EEC on the protection of workers from risks to exposure to biological agents at work?**

Yes (.) No (X)

If yes, specify

**5. Do the donor and recipient organism exchange genetic material naturally?**

Yes (.) No (X) Not known (.)

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**E. INFORMATION RELATING TO THE GENETICALLY MODIFIED ORGANISM**

**1. Genetic traits and phenotypic characteristics of the recipient or parental organism which have been changed as a result of the genetic modification**

**(a) is the GMO different from the recipient as far as survivability is concerned?**

Yes (.) No (X) Not known (.)

Specify:

**(b) is the GMO in any way different from the recipient as far as mode and/or rate of reproduction is concerned?**

Yes (X) No (.) Not known (.)

Specify:

The HSV-1 protein ICP34.5 normally promotes neurovirulence by allowing the virus to replicate in non-dividing cells such as neurons. Both copies of ICP34.5 are functionally deleted from talimogene laherparepvec, preventing the virus from replicating efficiently in non-dividing cells.

**(c) is the GMO in any way different from the recipient as far as dissemination is concerned?**

Yes (X) No (.) Not known (.)

Specify:

The functional deletion of ICP34.5 in talimogene laherparepvec significantly decreases the ability of the virus to replicate in non-dividing cells.

**(d) is the GMO in any way different from the recipient as far as pathogenicity is concerned?**

Yes (X) No (.) Not known (.)

Specify:

The functional deletion of ICP34.5 in talimogene laherparepvec significantly decreases virulence compared to wild-type HSV-1. Talimogene laherparepvec is therefore significantly attenuated in normal cells. Virus mediated toxicity is therefore likely to be minimal.

Strains of HSV-1 lacking ICP34.5 have been extensively utilised without incident in a variety of animal models and also in several human clinical trials.

**2. Genetic stability of the genetically modified organism**

The genetic stability of talimogene laherparepvec is expected to be the same as wild-type HSV-1. i.e. stable in isolation but with the potential for homologous recombination with other HSV-1 viruses if they simultaneously infect the same (human) cell.



The genetic stability of talimogene laherparepvec in isolation (i.e. in the absence of a co-infecting different strain of HSV-1) has been demonstrated and continues to be monitored.

A spontaneously occurring genetic variant of talimogene laherparepvec would require an initial recombination event(s) leading to the creation of the genetic variant itself. It is unlikely that a wild-type virus would be in the same tissue as talimogene laherparepvec in subjects since the latter is directly injected into tumour cells and cannot spread effectively into normal tissue, while the pre-existing HSV-1 would be in the mucosal tissues or neuronal ganglia of the patient. The possibility of the creation of stable genetic variants with unintended characteristics is also minimised by the design of the talimogene laherparepvec genetic construct.

**3. Is the GMO significantly pathogenic or harmful in any way (including its extracellular products), either living or dead?**

Yes (.) No (X) Not known (.)

**(a) to which of the following organisms?**

humans (.)

animals (.)

plants (.)

others (.)

**(b) give the relevant information specified under Annex III A, point II(A)(11)(d) and II(C)(2)(i)**

**4. Description of identification and detection methods**

**(a) Techniques used to detect the GMO in the environment**

The same techniques used to detect the parental organism can be used to detect talimogene laherparepvec.

Viral culture (plaque assay; Dulbecco, 1952) can be used to detect talimogene laherparepvec and wild-type HSV-1 in swabs or other samples, although this assay only detects live virus and does not discriminate between talimogene laherparepvec and wild-type HSV-1

A qPCR assay has been developed which can be used to detect talimogene laherparepvec specifically. The qPCR assay does not detect whether the talimogene

laherparepvec detected is viable, but it does distinguish between talimogene laherparepvec and wild-type HSV-1. Wild-type HSV-1 is not detected by this test as the primers for the PCR amplification are specific for talimogene laherparepvec gene sequences. The qPCR assay allows highly sensitive and specific detection of DNA sequences as well as quantification of the target sequence.

To confirm the viral infectivity, the virus titration using 50% tissue culture infectious dose (TCID<sub>50</sub>) end-point assay has been developed. The intended use of the assay is for the quantitative detection of talimogene laherparepvec by TCID<sub>50</sub> in human specimens from lesions representative of HSV-1 infection following detection by real-time PCR.

**(b) Techniques used to identify the GMO**

In the proposed clinical trial (20140318), qPCR and TCID<sub>50</sub> (described above) will be used for detection and identification of talimogene laherparepvec in specified human samples as defined in the clinical trial protocol.

**F. INFORMATION RELATING TO THE RELEASE**

**1. Purpose of the release (including any significant potential environmental benefits that may be expected)**

The purpose of the release is to conduct a phase 1, Multicenter, Open-label Trial to Evaluate the Safety of Talimogene Laherparepvec Injected into Liver Tumors (Protocol 20140318)

**2. Is the site of the release different from the natural habitat or from the ecosystem in which the recipient or parental organism is regularly used, kept or found?**

Yes (X) No (.)

If yes, specify

The site of release will be a medical facility approved to conduct this clinical trial.

**3. Information concerning the release and the surrounding area**

**(a) Geographical location (administrative region and where appropriate grid reference):**

Participating sites in Spain are as follows:

Name of the site	Address
Hospital Universitario Madrid Sanchinarro	Oña, 10 28050 Madrid
Hospital Clínic i provincial de Barcelona	Villarroel 170, 08036 Barcelona
Hospital General Universitario Gregorio Marañón	Dr Esquerdo, 46 28007 Madrid

**(b) Size of the site (m<sup>2</sup>):**

(i) actual release site (m<sup>2</sup>):

(ii) wider release site (m<sup>2</sup>):

The size of each site will vary but it is important to note that contamination of the site at which the administration is performed is expected to be minimal, when suitable precautions are adhered to.

**(c) Proximity to internationally recognised biotopes or protected areas (including drinking water reservoirs), which could be affected:**

Given the nature of the product administration directly into the subject's tumours, and procedures for waste treatment, the exposure to significant biotopes, protected areas and drinking water supplies is expected to be minimal. Since humans are the only

natural host for wild type HSV-1 infection with no known vector, proximity to other biotopes is not a concern. The genetic modifications made to the parental virus in the construction of talimogene laherparepvec do not affect its selectivity to the host species. The stability of talimogene laherparepvec in the environment is also unchanged from that of wild-type HSV-1, and will rapidly lose viability outside the target species.

**(d) Flora and fauna including crops, livestock and migratory species which may potentially interact with the GMO**

Since humans are the only natural host for wild type HSV-1 infection with no known vector, proximity to other flora and fauna is not a concern.

**4. Method and amount of release**

**(a) Quantities of GMOs to be released:**

Vials containing 1.15 mL of talimogene laherparepvec will be supplied to study site pharmacies in two strengths;  $10^6$  PFU/mL or  $10^8$  PFU/mL.

The maximum volume of talimogene laherparepvec administered at any dose is up to 8.0 mL for any individual lesion. The maximum dose in any one treatment is up to 8.0 mL.

**(b) Duration of the operation:**

The estimated average per-subject study duration is approximately 32 months. Due to the mechanism of action of talimogene laherparepvec, dosing should be continued for at least 6 months from the time of initial dose, provided that the subject has no evidence of clinically significant deterioration of health status requiring discontinuation of treatment with talimogene laherparepvec and is able to tolerate the treatment.

**(c) Methods and procedures to avoid and/or minimise the spread of the GMOs beyond the site of the release:**

Distribution and supply:

Talimogene laherparepvec is an investigational medicinal product for use only in approved clinical trials by trained medical professionals at an authorised study site.

It will be supplied by Amgen directly to the study site and appropriate records/ traceability of shipments will be maintained in line with the requirements of Good Clinical Practice (GCP).

Talimogene laherparepvec is provided as a sterile, single use, preservative-free frozen liquid in a cyclic olefin polymer (COP) plastic resin vial with an elastomeric stopper and an aluminium seal with flip-off dust cover.

Storage:

Talimogene laherparepvec must be stored in a secure, temperature monitored freezer at -70°C or below in the pharmacy or other appropriate secure location until planned use.

Dose preparation and administration:

Precautions to be adhered to during dose preparation and administration are outlined in the Investigational Product Instruction Manual (IPIM), which is supplied to each study site.

It is appropriate to dispense vials of drug such that product is then drawn up into syringes in the room used for product administration, although this may also optionally occur elsewhere, e.g., in the pharmacy, although local institutional guidelines must also be followed.

The injection site should be swabbed with alcohol before and following injection, and then covered with a dry occlusive dressing before the patient leaves the medical facility. The occlusive dressing covers the injection site for up to 1 week. Given the nature of the product administration directly into the patient's tumours, the use of an occlusive dressing provides a physical barrier to virus leakage. The low levels of shedding observed during clinical development minimises the risk of exposure of the medical professionals involved in the patients' care and the patients' family on returning home from the study site facility to talimogene laherparepvec.

Spills:

In the context of this clinical trial, spills are unlikely to constitute a volume greater than 8 mL (i.e. 8 vials). Spills should be treated with a virucidal agent. All materials contaminated with talimogene laherparepvec must be disposed of in compliance with local institutional guidelines.

Disposal:

The genetic modifications made during the construction of talimogene laherparepvec from wild-type HSV-1 do not affect its sensitivity to physical and chemical inactivation.

Physical inactivation:

Wild-type HSV virus is easily inactivated outside the host by exposure to pH <4, temperatures >56°C for 30 min, pasteurization (60°C for 10 h), and microwave heating for 4 min (Croughan & Behbehani 1988, Jerome & Morrow 2007).

Chemical inactivation:

Wild-type HSV virus is easily inactivated by lipid solvents (Jerome & Morrow 2007). It can be inactivated by 0.5% Lysol in 5 min; by Listerine (1:1 mixtures) in 5 min; by 2,000 ppm (2,000 µL/L) of bleach in 10 min; by 70% isopropyl alcohol (1:1 mixtures) (Croughan & Behbehani 1988). HSV is also susceptible to quaternary ammonium compounds (Wood and Payne, 1998). Most herpes viruses are also susceptible to 30% ethanol and isopropanol, 0.12% orthophenyl phenol, and 0.04% glutaraldehyde (Prince & Prince, 2001).

Susceptibility to anti-viral agents:

Antiviral medicinal products like acyclovir, valacyclovir and famciclovir can be used to inhibit wild-type HSV-1 replication (Drew 2004, Usitane and Tinitigan 2010) and are expected to be effective against talimogene laherparepvec. The in vitro sensitivity of talimogene laherparepvec to acyclovir has been demonstrated

Following administration of talimogene laherparepvec at the study site, materials used during injection (e.g., gloves, needles, gauze) will be disposed of in accordance with local/regional and institutional requirements for biohazardous waste.

**5. Short description of average environmental conditions (weather, temperature, etc.)**

The risk of release of talimogene laherparepvec in to the environment is unrelated to climatic characteristics.

**6. Relevant data regarding previous releases carried out with the same GMO, if any, specially related to the potential environmental and human health impacts from the release.**

As of May 2014 (reporting period for the Talimogene laherparepvec Investigator's Brochure Edition 12.0, dated 09 October 2014), ten clinical studies have been or are being conducted in several advanced tumour types (advanced solid tumours, melanoma, squamous cell cancer of the head and neck (SCCHN), and pancreatic cancer) with a total of 430 patients treated with talimogene laherparepvec.

After intratumoural injection, talimogene laherparepvec is only transiently detected in patients' blood and urine. Talimogene laherparepvec DNA has also be detected on the surface of injected tumours, and in one ongoing study, on the exterior of the dressing at low levels. No infectious virus could be detected in these samples. No evidence of herpes infection attributable to talimogene laherparepvec outside of the tumour has been documented. In some studies a number of individuals (patients or medical personnel)

had reports of oral lesions but where these were tested by culture of the virus and PCR analysis the causative agent was wild-type HSV (reactivating endogenous HSV) and not talimogene laherparepvec. It should be noted that reactivation of wild-type HSV-1 would not be unexpected in the population as a whole.

**G. INTERACTIONS OF THE GMO WITH THE ENVIRONMENT AND POTENTIAL IMPACT ON THE ENVIRONMENT, IF SIGNIFICANTLY DIFFERENT FROM THE RECIPIENT OR PARENT ORGANISM**

**1. Name of target organism (if applicable)**

- |        |   |                      |
|--------|---|----------------------|
| (i)    | order and/or higher taxon (for animals) | Primate              |
| (ii)   | family name for plants                  |                      |
| (iii)  | genus                                   | Homo                 |
| (iv)   | species                                 | Homo Sapiens         |
| (v)    | subspecies                              | Homo Sapiens Sapiens |
| (vi)   | strain                                  |                      |
| (vii)  | cultivar/breeding line                  |                      |
| (viii) | pathovar                                |                      |
| (ix)   | common name                             | Humans               |

**2. Anticipated mechanism and result of interaction between the released GMOs and the target organism (if applicable)**

Talimogene laherparepvec has been engineered to replicate selectively in tumours, killing tumour cells by viral lysis, followed by spread of talimogene laherparepvec within the tumour and further tumour cell lysis. Additionally, the oncolysis of tumour cells by talimogene laherparepvec also releases and exposes an array of antigens to initiate a systemic immune response, and this is augmented through the expression of an immune stimulatory protein, hGM-CSF from the virus. Released tumour antigens are expected to be taken up by antigen presenting cells (APCs) which then traffic to lymph nodes and present to T cells, inducing an immune response. hGM-CSF increases the activity of APCs, enhancing the immune responses. This immune response is intended to provide a systemic anti-tumour effect, including the shrinkage of tumours which do not come into direct contact with talimogene laherparepvec, reduction of micrometastatic disease, and protection against future relapse.

**3. Any other potentially significant interactions with other organisms in the environment**

Talimogene laherparepvec is an attenuated version of HSV-1, modified so that replication occurs selectively in tumour cells in the target human population and is therefore self-limiting. As with wild-type HSV-1 it is not known to colonise other species, nor are other species known to be carriers or vectors under natural conditions. Considerable literature shows that HSV-1 deleted for ICP34.5 has been extensively utilised without incident in animals and humans.



**4. Is post-release selection such as increased competitiveness, increased invasiveness for the GMO likely to occur?**

Yes (.) No (X) Not known (.)

Give details

Talimogene laherparepvec is modified so that replication occurs selectively in tumour cells in the target human population and is therefore self-limiting.

**5. Types of ecosystems to which the GMO could be disseminated from the site of release and in which it could become established**

Humans are the only natural host for wild-type HSV-1 infection and the genetic modifications introduced in the construction of talimogene laherparepvec do not affect host range but do attenuate its replicative capacity in normal cells through the functional deletion of ICP34.5.

Dissemination could therefore only occur between human beings. However the ICP34.5 gene deletion is intended to allow only tumour selective replication and limited or no viral replication in normal tissues.

**6. Complete name of non-target organisms which (taking into account the nature of the receiving environment) may be unintentionally significantly harmed by the release of the GMO**

- (i) order and/or higher taxon (for animals)
- (ii) family name for plants
- (iii) genus
- (iv) species
- (v) subspecies
- (vi) strain
- (vii) cultivar/breeding line
- (viii) pathovar
- (ix) common name

**7. Likelihood of genetic exchange in vivo**

**(a) from the GMO to other organisms in the release ecosystem:**

Humans are the only natural host for wild-type HSV-1 infection. No transfer into other organisms is expected.

The transfer of genetic material is therefore limited to the virally mediated (non integrative) transfer of the viral DNA between humans and theoretically, genetic

exchange between two wild-type HSV-1 strains by homologous recombination which could only occur if human cells were simultaneously infected with both strains.

A spontaneously occurring genetic variant of talimogene laherparepvec would require an initial recombination event(s) leading to the creation of the genetic variant itself. It is unlikely that a wild-type HSV-1 virus would be in the same tissue as talimogene laherparepvec since the latter is directly injected into tumour cells and cannot spread effectively into normal tissue, while the pre-existing HSV-1 would be in the mucosal tissues or neuronal ganglia of the patient. The possibility of the creation of stable genetic variants with unintended characteristics is also minimised by the design of the talimogene laherparepvec genetic construct.

**(b) from other organisms to the GMO:**

See section G.7(a) above

**(c) likely consequences of gene transfer:**

The design of the talimogene laherparepvec genetic construct is such that the inserted gene is located in the region of the ICP 34.5 deletions. Thus, restoration of ICP34.5 will cause a simultaneous deletion of the hGM-CSF insert (and vice versa). It is considered that any stable (homozygous) produced in this way will pose a greater hazard than the wild-type HSV-1 co-infection itself.

**8. Give references to relevant results (if available) from studies of the behaviour and characteristics of the GMO and its ecological impact carried out in stimulated natural environments (e.g. microcosms, etc.):**

Talimogene laherparepvec is an attenuated version of wild-type HSV-1. The genetic modifications do not affect its natural host range, which is restricted to humans.

No specific studies have been conducted regarding transmission of talimogene laherparepvec between humans as such studies would be unethical.

It is not possible to model human transmission between treated and untreated animals since transmission of wild-type HSV-1 between animals is not known to occur in nature, and the genetic modifications made to wild-type HSV-1 resulting in talimogene laherparepvec attenuate the virus, further reducing the likelihood of transmission.

Biodistribution and virus shedding has however been monitored in both humans and animals following administration of talimogene laherparepvec (see Section F.6)

**9. Possible environmentally significant interactions with biogeochemical processes (if different from the recipient or parental organism)**

None known or predicted.

## **H. INFORMATION RELATING TO MONITORING**

### **1. Methods for monitoring the GMOs**

Monitoring of the direct and indirect effects of talimogene laherparepvec in subjects will be achieved by the clinical assessments defined in the clinical trial protocol. Study investigators will monitor subjects throughout treatment and will report adverse effects to Amgen Global Safety according to the requirements stipulated in the protocol.

Amgen will conduct a surveillance program to aid the assessment of any potential risks to third parties following treatment of subjects with talimogene laherparepvec.

### **2. Methods for monitoring ecosystem effects**

Since humans are the only natural host for wild-type HSV-1 infection, no plans for monitoring other organisms are considered necessary.

### **3. Methods for detecting transfer of the donated genetic material from the GMO to other organisms**

See Section E.4.

### **4. Size of the monitoring area (m2)**

Not applicable

### **5. Duration of the monitoring**

Monitoring will occur throughout the subject's participation in the study, including a period of safety follow-up, as defined in the study protocol, upon permanent discontinuation from the study.

### **6. Frequency of the monitoring**

Clinical assessments will be made according to the predefined schedule detailed in the study protocol. At each visit, the subject must be interviewed regarding their knowledge of any possible exposures or events that may have occurred in their close contacts.

The investigator is responsible for ensuring that all SAEs and AEs observed by the investigator or reported by the subject that occur after signing of the informed consent through to a predefined period after the last dose of study medication are recorded in the subject's medical record and are submitted to Amgen. Any SAE must be submitted to Amgen within 24 hours following the investigator's knowledge of the event.

## **I. INFORMATION ON POST-RELEASE AND WASTE TREATMENT**

### **1. Post-release treatment of the site**

Treatment of the study site facility after use will not be necessary, provided the advised handling precautions are adhered to when administering the product or when dealing with accidental spillages and breakages. However, work surfaces shall be decontaminated using a chemical disinfectant capable of virucidal activity following preparation and dosing of talimogene laherparepvec.

### **2. Post-release treatment of the GMOs**

Please refer to section I.3.(b).

### **3. (a) Type and amount of waste generated**

Waste generated from i.i. administration of talimogene laherparepvec will be limited to:

- Used vials and needles
- Used swabs and items used to clean injected area
- Used dressings applied to the injection sites
- Personal Protective Equipment used at the point of administration and when replacing or removing the used dressing.

Vials containing 1.15 mL of talimogene laherparepvec supplied to pharmacies will be provided in two strengths;  $10^6$  PFU/mL or  $10^8$  PFU/mL.

The maximum possible total dose for an individual patient is up to 8 mL (or 8 vials) per treatment. A treatment duration of 9 months would require a maximum total of 96 vials per subject.

Each administration will result in the maximum possible waste identified above.

### **3. (b) Treatment of waste**

Talimogene laherparepvec is sensitive to inactivation by a variety of commonly available physical and chemical methods (see Section F.4.(c)).

Since talimogene laherparepvec will be administered in a medical facility, all associated waste will be disposed of in line with standard practice for medical waste.

The information leaflet provided to each subject instructs that disposal of any soiled dressings should occur via the study site at their next scheduled visit. The subject is provided with additional dressings, disposable gloves and resealable bags, and specific instructions to be followed to minimise the risk of unintended exposure to the environment.

## **J. INFORMATION ON EMERGENCY RESPONSE PLANS**

### **1. Methods and procedures for controlling the dissemination of the GMO(s) in case of unexpected spread**

The only organism which may act as a mechanism for the spread of talimogene laherparepvec are humans, since humans are the only natural host for wild-type HSV-1 infection and is not known to be zoonotic or reverse zoonotic under natural conditions.

Talimogene laherparepvec is an attenuated version of HSV-1, modified so that replication occurs selectively in tumour cells. Considerable literature shows that HSV-1 deleted for ICP34.5 has been extensively utilised without incident in animals and humans.

Because the virus is attenuated in normal cells, exposure is highly unlikely to lead to replication and shedding in those not intended to receive the treatment. As such, the likelihood of spread is very low.

In the unlikely event of the transmission of talimogene laherparepvec to an unintended human recipient, the affected patient can be treated with approved antiviral treatments such as acyclovir, if clinically indicated to alleviate any symptoms of primary infection and potential recurrence (if deemed necessary). Further spread from the individual can be mitigated by educational materials to increase awareness of the infection and preventative measures which can be taken to prevent transmission to close contacts.

Any spread of talimogene laherparepvec to unintended human recipients is likely to be isolated to single cases in discrete geographical locations. The risk of widespread infection is considered negligible.

### **2. Methods for removal of the GMO(s) of the areas potentially affected**

Talimogene laherparepvec cannot persist outside its host organism for long periods and maintain viability. Since it is sensitive to even moderately harsh conditions, it is considered highly unlikely that spread would occur in the environment from fomites and talimogene laherparepvec would quickly be rendered non-viable by the prevailing conditions.

Decontamination of areas in which a recently treated patient had frequented (their home and or examination room at a medical facility) could be implemented by applying chemical disinfectants capable of virucidal activity to areas of likely contact.

**3. Methods for disposal or sanitation of plants, animals, soils, etc. that could be exposed during or after the spread**

Decontamination of plants, (non-human) animals and soils will not be required, since humans are the only natural host and will rapidly become non-viable outside a human host.

**4. Plans for protecting human health and the environment in the event of an undesirable effect**

There are no plans for isolation of an area should horizontal transfer occur between a patient receiving talimogene laherparepvec and an unintended human recipient.

Measures outlined above in Section J.1 may be implemented to reduce the risk of further spread.

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