NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Single technology appraisal (STA)

EXTRACT FROM MANUFACTURER'S APPENDICES

Sofosbuvir – Chronic hepatitis C

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Figure 89 Cost-effectiveness acceptability curve for SOF+RBV (24 weeks) versus PEG-IFN-2a+RBV (48 weeks) in GT3 TE IFN eligible**Error! Bookmark not defined.**
Figure 90 Tornado diagram for SOF+PEG-IFN-2a+RBV (12 weeks) versus PEG-IFN-2a+RBV (48 weeks) in GT1 TN IFN eligible using data from the MTC 505
Figure 91 Tornado diagram for SOF+PEG-IFN+RBV (12 weeks) versus Boceprevir+PEG-IFN-2b+RBV (48 weeks) in GT1 TN IFN eligible using data from the MTC 505
Figure 92 Tornado diagram for SOF+PEG-IFN-2a+RBV (12 weeks) versus Telaprevir+PEG-IFN-2a+RBV in GT1 TN IFN eligible using data from the MTC 507
Figure 93 Tornado diagram for SOF+RBV (12 weeks) versus PEG-IFN-2a+RBV (24 weeks) in GT2 TN IFN eligible using data from the MTC509

10 Appendices

10.1 *Appendix 1- Summary of Product Characteristics*

▼This medicinal product is subject to additional monitoring. This will allow quick identification of new safety information. Healthcare professionals are asked to report any suspected adverse reactions. See section 4.8 for how to report adverse reactions.

1. NAME OF THE MEDICINAL PRODUCT

Sovaldi 400 mg film-coated tablets

2. QUALITATIVE AND QUANTITATIVE COMPOSITION

Each film-coated tablet contains 400 mg of sofosbuvir.

For the full list of excipients, see section 6.1.

3. PHARMACEUTICAL FORM

Film-coated tablet.

Yellow, capsule-shaped, film-coated tablet of dimensions 20 mm x 9 mm, debossed on one side with “GSI” and “7977” on the other side.

4. Clinical particulars

4.1 Therapeutic indications

Sovaldi is indicated in combination with other medicinal products for the treatment of chronic hepatitis C (CHC) in adults (see sections 4.2, 4.4 and 5.1).

For hepatitis C virus (HCV) genotype specific activity, see sections 4.4 and 5.1.

4.2 Posology and method of administration

Sovaldi treatment should be initiated and monitored by a physician experienced in the management of patients with CHC.

Posology
The recommended dose is one 400 mg tablet, taken orally, once daily with food (see section 5.2).

Sovaldi should be used in combination with other medicinal products. Monotherapy of Sovaldi is not recommended (see section 5.1). Refer also to the Summary of Product Characteristics of the medicinal products that are used in combination with Sovaldi. The

recommended co-administered medicinal product(s) and treatment duration for Sovaldi combination therapy are provided in Table 1.

Table 1: Recommended co-administered medicinal product(s) and treatment duration for Sovaldi combination therapy

Patient population*	Treatment	Duration
Patients with genotype 1, 4, 5 or 6 CHC	Sovaldi + ribavirin + peginterferon alfa	12 weeks[a,b]
	Sovaldi + ribavirin Only for use in patients ineligible or intolerant to peginterferon alfa (see section 4.4)	24 weeks
Patients with genotype 2 CHC	Sovaldi + ribavirin	12 weeks[b]
Patients with genotype 3 CHC	Sovaldi + ribavirin + peginterferon alfa	12 weeks[b]
	Sovaldi + ribavirin	24 weeks
Patients with CHC awaiting liver transplantation	Sovaldi + ribavirin	Until liver transplantation[c]

* Includes patients co-infected with human immunodeficiency virus (HIV).

a. For previously treated patients with HCV genotype 1 infection, no data exists with the combination of Sovaldi, ribavirin and peginterferon alfa (see section 4.4).

b. Consideration should be given to potentially extending the duration of therapy beyond 12 weeks and up to 24 weeks; especially for those subgroups who have one or more factors historically associated with lower response rates to interferon-based therapies (e.g. advanced fibrosis/cirrhosis, high baseline viral concentrations, black race, IL28B non CC genotype, prior null response to peginterferon alfa and ribavirin therapy).

c. See Special patient populations – Patients awaiting liver transplantation below.

The dose of ribavirin, when used in combination with Sovaldi is weight-based (<75 kg = 1,000 mg and ≥75 kg = 1,200 mg) and administered orally in two divided doses with food.

Concerning co-administration with other direct-acting antivirals against HCV, see section 4.4.

Dose modification
Dose reduction of Sovaldi is not recommended.

If sofosbuvir is used in combination with peginterferon alfa, and a patient has a serious adverse reaction potentially related to this drug, the peginterferon alfa dose should be reduced or discontinued. Refer to the peginterferon alfa Summary of Product Characteristics for additional information about how to reduce and/or discontinue the peginterferon alfa dose.

If a patient has a serious adverse reaction potentially related to ribavirin, the ribavirin dose should be modified or discontinued, if appropriate, until the adverse reaction abates or decreases in severity. Table 2 provides guidelines for dose modifications and discontinuation based on the patient's haemoglobin concentration and cardiac status.

Table 2: Ribavirin dose modification guideline for co-administration with Sovaldi

Laboratory values	Reduce ribavirin dose to 600 mg/day if:	Discontinue ribavirin if:
Haemoglobin in subjects with no cardiac disease	<10 g/dL	<8.5 g/dL
Haemoglobin in subjects with history of stable cardiac disease	≥2 g/dL decrease in haemoglobin during any 4 week period treatment	<12 g/dL despite 4 weeks at reduced dose

Once ribavirin has been withheld due to either a laboratory abnormality or clinical manifestation, an attempt may be made to restart ribavirin at 600 mg daily and further increase the dose to 800 mg daily. However, it is not recommended that ribavirin be increased to the original assigned dose (1,000 mg to 1,200 mg daily).

Discontinuation of dosing
If the other medicinal products used in combination with Sovaldi are permanently discontinued, Sovaldi should also be discontinued (see section 4.4).

Special patient populations
Elderly
No dose adjustment is warranted for elderly patients (see section 5.2).

Renal impairment
No dose adjustment of Sovaldi is required for patients with mild or moderate renal impairment. The safety and appropriate dose of Sovaldi have not been established in patients with severe renal impairment (estimated glomerular filtration rate [eGFR] <30 mL/min/1.73 m^2) or end stage renal disease (ESRD) requiring haemodialysis (see section 5.2).

Hepatic impairment
No dose adjustment of Sovaldi is required for patients with mild, moderate or severe hepatic impairment (Child-Pugh-Turcotte [CPT] class A, B or C) (see section 5.2). The safety and efficacy of Sovaldi have not been established in patients with decompensated cirrhosis.

Patients awaiting liver transplantation
The duration of administration of Sovaldi in patients awaiting liver transplantation should be guided by an assessment of the potential benefits and risks for the individual patient (see section 5.1).

Paediatric population
The safety and efficacy of Sovaldi in children and adolescents aged <18 years have not yet been established. No data are available.

Method of administration
The film-coated tablet is for oral use. Patients should be instructed to swallow the tablet whole. The film-coated tablet should not be chewed or crushed, due to the bitter taste of the active substance. The tablet should be taken with food (see section 5.2).

Patients should be instructed that if vomiting occurs within 2 hours of dosing an additional tablet should be taken. If vomiting occurs more than 2 hours after dosing, no further dose is needed. These recommendations are based on the absorption kinetics of sofosbuvir and GS-331007 suggesting that the majority of the dose is absorbed within 2 hours after dosing.

If a dose is missed and it is within 18 hours of the normal time, patients should be instructed to take the tablet as soon as possible and then patients should take the next dose at the usual time. If it is after 18 hours then patients should be instructed to wait and take the next dose at the usual time. Patients should be instructed not to take a double dose.

4.3 Contraindications

Hypersensitivity to the active substance or to any of the excipients listed in section 6.1.

4.4 Special warnings and precautions for use

General
Sovaldi is not recommended for administration as monotherapy and should be prescribed in combination with other medicinal products for the treatment of hepatitis C infection. If the other medicinal products used in combination with Sovaldi are permanently discontinued, Sovaldi should also be discontinued (see section 4.2). Consult the Summary of Product Characteristics for co-prescribed medicinal products before starting therapy with Sovaldi.

Treatment-experienced patients with genotype 1, 4, 5 and 6 HCV infection
Sovaldi has not been studied in a Phase 3 study in treatment-experienced patients with genotype 1, 4, 5 and 6 HCV infection. Thus, the optimal treatment duration in this population has not been established (see also sections 4.2 and 5.1).

Consideration should be given to treating these patients, and potentially extending the duration of therapy with sofosbuvir, peginterferon alfa and ribavirin beyond 12 weeks and up to 24 weeks; especially for those subgroups who have one or more factors historically associated with lower response rates to interferon-based therapies (advanced fibrosis/cirrhosis, high baseline viral concentrations, black race, IL28B non CC genotype).

Treatment of patients with genotype 5 or 6 HCV infection
The clinical data to support the use of Sovaldi in patients with genotype 5 and 6 HCV infection is very limited (see section 5.1).

Interferon-free therapy for genotype 1, 4, 5 and 6 HCV infection
Interferon-free regimens for patients with genotype 1, 4, 5 and 6 HCV infection with Sovaldi have not been investigated in Phase 3 studies (see section 5.1). The optimal regimen and treatment duration have not been established. Such regimens should only be used for patients that are intolerant to or ineligible for interferon therapy, and are in urgent need of treatment.

Co-administration with other direct-acting antivirals against HCV
Sovaldi should only be co-administered with other direct-acting antiviral medicinal products if the benefit is considered to outweigh the risks based upon available data. There are no data to support the co-administration of Sovaldi and telaprevir or boceprevir. Such co-administration is not recommended (see also section 4.5).

Pregnancy and concomitant use with ribavirin
When Sovaldi is used in combination with ribavirin or peginterferon alfa/ribavirin, women of childbearing potential or their male partners must use an effective form of contraception during the treatment and for a period of time after the treatment as recommended in the Summary of Product Characteristics for ribavirin. Refer to the Summary of Product Characteristics for ribavirin for additional information.

Use with potent P-gp inducers
Medicinal products that are potent P-glycoprotein (P-gp) inducers in the intestine (e.g. rifampicin, St. John's wort *[Hypericum perforatum]*, carbamazepine and phenytoin) may

significantly decrease sofosbuvir plasma concentration leading to reduced therapeutic effect of Sovaldi. Such medicinal products should not be used with Sovaldi (see section 4.5).

Renal impairment
The safety of Sovaldi has not been assessed in subjects with severe renal impairment (eGFR <30 mL/min/1.73 m^2) or ESRD requiring haemodialysis. Furthermore, the appropriate dose has not been established. When Sovaldi is used in combination with ribavirin or peginterferon alfa/ribavirin, refer also to the Summary of Product Characteristics for ribavirin for patients with creatinine clearance (CrCl) <50 mL/min (see also section 5.2).

HCV/HBV (hepatitis B virus) co-infection
There are no data on the use of Sovaldi in patients with HCV/HBV co-infection.

Paediatric population
Sovaldi is not recommended for use in children and adolescents under 18 years of age because the safety and efficacy have not been established in this population.

4.5 Interaction with other medicinal products and other forms of interaction

Sofosbuvir is a nucleotide prodrug. After oral administration of Sovaldi, sofosbuvir is rapidly absorbed and subject to extensive first-pass hepatic and intestinal metabolism. Intracellular hydrolytic prodrug cleavage catalysed by enzymes including carboxylesterase 1 and sequential phosphorylation steps catalysed by nucleotide kinases result in formation of the pharmacologically active uridine nucleoside analogue triphosphate. The predominant inactive circulating metabolite GS-331007 that accounts for greater than 90% of drug-related material systemic exposure is formed through pathways sequential and parallel to formation of active metabolite. The parent sofosbuvir accounts for approximately 4% of drug-related material systemic exposure (see section 5.2). In clinical pharmacology studies, both sofosbuvir and GS-331007 were monitored for purposes of pharmacokinetic analyses.

Sofosbuvir is a substrate of drug transporter P-gp and breast cancer resistance protein (BCRP) while GS-331007 is not. Medicinal products that are potent P-gp inducers in the intestine (e.g. rifampicin, St. John's wort, carbamazepine and phenytoin) may decrease sofosbuvir plasma concentration leading to reduced therapeutic effect of Sovaldi and thus should not be used with Sovaldi (see section 4.4). Co-administration of Sovaldi with medicinal products that inhibit P-gp and/or BCRP may increase sofosbuvir plasma concentration without increasing GS-331007 plasma concentration, thus Sovaldi may be co-administered with P-gp and/or BCRP inhibitors. Sofosbuvir and GS-331007 are not inhibitors of P-gp and BCRP and thus are not expected to increase exposures of medicinal products that are substrates of these transporters.

The intracellular metabolic activation pathway of sofosbuvir is mediated by generally low affinity and high capacity hydrolase and nucleotide phosphorylation pathways that are unlikely to be affected by concomitant medicinal products (see section 5.2).

Other interactions
Drug interaction information for Sovaldi with potential concomitant medicinal products is summarised in Table 3 below (where 90% confidence interval (CI) of the geometric least-squares mean (GLSM) ratio were within "↔", extended above "↑", or extended below "↓" the predetermined equivalence boundaries). The table is not all-inclusive.

Table 3: Interactions between Sovaldi and other medicinal products

Medicinal product by therapeutic areas	**Effects on drug levels. Mean ratio (90% confidence interval) for AUC, C_{max}, C_{min} [a,b]**	**Recommendation concerning co-administration with Sovaldi**
ANALEPTICS		
Modafinil	Interaction not studied. *Expected:* ↓ Sofosbuvir ↓ GS-331007	Co-administration of Sovaldi with modafinil is expected to decrease the concentration of sofosbuvir, leading to reduced therapeutic effect of Sovaldi. Such co-administration is not recommended.
ANTICONVULSANTS		
Carbamazepine Phenytoin Phenobarbital Oxcarbazepine	Interaction not studied. *Expected:* ↓ Sofosbuvir ↓ GS-331007	Co-administration of Sovaldi with carbamazepine, phenytoin, phenobarbital or oxcarbazepine is expected to decrease the concentration of sofosbuvir, leading to reduced therapeutic effect of Sovaldi. Such co-administration is not recommended. Sovaldi should not be used with carbamazepine, phenytoin, phenobarbital or oxcarbazepine, potent intestinal P-gp inducers (see section 4.4).
ANTIMYCOBACTERIALS		
Rifabutin Rifampicin Rifapentine	Interaction not studied. *Expected:* ↓ Sofosbuvir ↓ GS-331007	Co-administration of Sovaldi with rifabutin or rifapentine is expected to decrease the concentration of sofosbuvir, leading to reduced therapeutic effect of Sovaldi. Such co-administration is not recommended. Sovaldi should not be used with rifampicin, a potent intestinal P-gp inducer (see section 4.4).
HERBAL SUPPLEMENTS		
St. John's wort *(Hypericum perforatum)*	Interaction not studied. *Expected:* ↓ Sofosbuvir ↓ GS-331007	Sovaldi should not be used with St. John's wort, a potent intestinal P-gp inducer (see section 4.4).
HCV ANITIVIRAL AGENTS: HCV PROTEASE INHIBITORS		
Boceprevir (BOC) Telaprevir (TPV)	Interaction not studied. *Expected:* ↑ Sofosbuvir (TPV) ↔ Sofosbuvir (BOC) ↔ GS-331007 (TPV or BOC)	No drug-drug interactio data exists regarding the co-administration of Sovaldi with boceprevir or telaprevir.

Medicinal product by therapeutic areas	Effects on drug levels. Mean ratio (90% confidence interval) for AUC, C_{max}, C_{min}[a,b]	Recommendation concerning co-administration with Sovaldi
NARCOTIC ANALGESICS		
Methadone[f] (Methadone maintenance therapy [30 to 130 mg/daily])	*R-methadone* ↔ C_{max} 0.99 (0.85, 1.16) ↔ AUC 1.01 (0.85, 1.21) ↔ C_{min} 0.94 (0.77, 1.14) *S-methadone* ↔ C_{max} 0.95 (0.79, 1.13) ↔ AUC 0.95 (0.77, 1.17) ↔ C_{min} 0.95 (0.74, 1.22) *Sofosbuvir* ↓ C_{max} 0.95[c] (0.68, 1.33) ↑ AUC 1.30[c] (1.00, 1.69) C_{min} (NA) *GS-331007* ↓ C_{max} 0.73[c] (0.65, 0.83) ↔ AUC 1.04[c] (0.89, 1.22) C_{min} (NA)	No dose adjustment of sofosbuvir or methadone is required when sofosbuvir and methadone are used concomitantly.
IMMUNOSUPPRESSANTS		
Ciclosporin[e] (600 mg single dose)	*Ciclosporin* ↔ C_{max} 1.06 (0.94, 1.18) ↔ AUC 0.98 (0.85, 1.14) C_{min} (NA) *Sofosbuvir* ↑ C_{max} 2.54 (1.87, 3.45) ↑ AUC 4.53 (3.26, 6.30) C_{min} (NA) *GS-331007* ↓ C_{max} 0.60 (0.53, 0.69) ↔ AUC 1.04 (0.90, 1.20) C_{min} (NA)	No dose adjustment of sofosbuvir or ciclosporin is required when sofosbuvir and ciclosporin are used concomitantly.
Tacrolimus[e] (5 mg single dose)	*Tacrolimus* ↓ C_{max} 0.73 (0.59, 0.90) ↔ AUC 1.09 (0.84, 1.40) C_{min} (NA) *Sofosbuvir* ↓ C_{max} 0.97 (0.65, 1.43) ↑ AUC 1.13 (0.81, 1.57) C_{min} (NA) *GS-331007* ↔ C_{max} 0.97 (0.83, 1.14) ↔ AUC 1.00 (0.87, 1.13) C_{min} (NA)	No dose adjustment of sofosbuvir or tacrolimus is required when sofosbuvir and tacrolimus are used concomitantly.

Medicinal product by therapeutic areas	**Effects on drug levels. Mean ratio (90% confidence interval) for AUC, C_{max}, C_{min}[a,b]**	**Recommendation concerning co-administration with Sovaldi**
HIV ANTIVIRAL AGENTS: REVERSE TRANSCRIPTASE INHIBITORS		
Efavirenz[f] (600 mg once daily)[d]	*Efavirenz* ↔ C_{max} 0.95 (0.85, 1.06) ↔ AUC 0.96 (0.91, 1.03) ↔ C_{min} 0.96 (0.93, 0.98) *Sofosbuvir* ↓ C_{max} 0.81 (0.60, 1.10) ↔ AUC 0.94 (0.76, 1.16) C_{min} (NA) *GS-331007* ↓ C_{max} 0.77 (0.70, 0.84) ↔ AUC 0.84 (0.76, 0.92) C_{min} (NA)	No dose adjustment of sofosbuvir or efavirenz is required when sofosbuvir and efavirenz are used concomitantly.
Emtricitabine[f] (200 mg once daily)[d]	*Emtricitabine* ↔ C_{max} 0.97 (0.88, 1.07) ↔ AUC 0.99 (0.94, 1.05) ↔ C_{min} 1.04 (0.98, 1.11) *Sofosbuvir* ↓ C_{max} 0.81 (0.60, 1.10) ↔ AUC 0.94 (0.76, 1.16) C_{min} (NA) *GS-331007* ↓ C_{max} 0.77 (0.70, 0.84) ↔ AUC 0.84 (0.76, 0.92) C_{min} (NA)	No dose adjustment of sofosbuvir or emtricitabine is required when sofosbuvir and emtricitabine are used concomitantly.
Tenofovir disoproxil fumarate[f] (300 mg once daily)[d]	*Tenofovir* ↑ C_{max} 1.25 (1.08, 1.45) ↔ AUC 0.98 (0.91, 1.05) ↔ C_{min} 0.99 (0.91, 1.07) *Sofosbuvir* ↓ C_{max} 0.81 (0.60, 1.10) ↔ AUC 0.94 (0.76, 1.16) C_{min} (NA) *GS-331007* ↓ C_{max} 0.77 (0.70, 0.84) ↔ AUC 0.84 (0.76, 0.92) C_{min} (NA)	No dose adjustment of sofosbuvir or tenofovir disoproxil fumarate is required when sofosbuvir and tenofovir disoproxil fumarate are used concomitantly.

Medicinal product by therapeutic areas	**Effects on drug levels. Mean ratio (90% confidence interval) for AUC, C_{max}, C_{min}[a,b]**	**Recommendation concerning co-administration with Sovaldi**
Rilpivirine[f] (25 mg once daily)	*Rilpivirine* ↔ C_{max} 1.05 (0.97, 1.15) ↔ AUC 1.06 (1.02, 1.09) ↔ C_{min} 0.99 (0.94, 1.04) *Sofosbuvir* ↑ C_{max} 1.21 (0.90, 1.62) ↔ AUC 1.09 (0.94, 1.27) C_{min} (NA) *GS-331007* ↔ C_{max} 1.06 (0.99, 1.14) ↔ AUC 1.01 (0.97, 1.04) C_{min} (NA)	No dose adjustment of sofosbuvir or rilpivirine is required when sofosbuvir and rilpivirine are used concomitantly.
HIV ANTIVIRAL AGENTS: HIV PROTEASE INHIBITORS		
Darunavir boosted with ritonavir[f] (800/100 mg once daily)	*Darunavir* ↔ C_{max} 0.97 (0.94, 1.01) ↔ AUC 0.97 (0.94, 1.00) ↔ C_{min} 0.86 (0.78, 0.96) *Sofosbuvir* ↑ C_{max} 1.45 (1.10, 1.92) ↑ AUC 1.34 (1.12, 1.59) C_{min} (NA) *GS-331007* ↔ C_{max} 0.97 (0.90, 1.05) ↔ AUC 1.24 (1.18, 1.30) C_{min} (NA)	No dose adjustment of sofosbuvir or darunavir (ritonavir boosted) is required when sofosbuvir and darunavir are used concomitantly.
HIV ANTIVIRAL AGENTS: INTEGRASE INHIBITORS		
Raltegravir[f] (400 mg once daily)	*Raltegravir* ↓ C_{max} 0.57 (0.44, 0.75) ↓ AUC 0.73 (0.59, 0.91) ↔ C_{min} 0.95 (0.81, 1.12) *Sofosbuvir* ↔ C_{max} 0.87 (0.71, 1.08) ↔ AUC 0.95 (0.82, 1.09) C_{min} (NA) *GS-331007* ↔ C_{max} 1.09 (0.99, 1.20) ↔ AUC 1.03 (0.97, 1.08) C_{min} (NA)	No dose adjustment of sofosbuvir or raltegravir is required when sofosbuvir and raltegravir are used concomitantly.

Medicinal product by therapeutic areas	Effects on drug levels. Mean ratio (90% confidence interval) for AUC, C_{max}, C_{min}[a,b]	Recommendation concerning co-administration with Sovaldi
ORAL CONTRACEPTIVES		
Norgestimate/ethinyl estradiol	*Norgestromin* ↔ C_{max} 1.06 (0.93, 1.22) ↔ AUC 1.05 (0.92, 1.20) C_{min} (NA) *Norgestrel* ↔ C_{max} 1.18 (0.99, 1.41) ↔ AUC 1.19 (0.98, 1.44) C_{min} (NA) *Ethinyl estradiol* ↔ C_{max} 1.14 (0.96, 1.36) ↔ AUC 1.08 (0.93, 1.25) C_{min} (NA)	No dose adjustment of norgestimate/ethinyl estradiol is required when sofosbuvir and norgestimate/ethinyl estradiol are used concomitantly.

NA = not available/not applicable
a. Mean ratio (90% CI) of co-administered drug pharmacokinetics with/without sofosbuvir and mean ratio of sofosbuvir and GS-331007 with/without co-administered drug. No effect = 1.00
b. All interaction studies conducted in healthy volunteers
c. Comparison based on historical control
d. Administered as Atripla
e. Bioequivalence boundary 80%-125%
f. Equivalence boundary 70%-143%

Medicinal products that are potent P-gp inducers in the intestine (rifampicin, St. John's wort, carbamazepine and phenytoin) may significantly decrease sofosbuvir plasma concentration leading to reduced therapeutic effect. For this reason, sofosbuvir should not be co-administered with known inducers of P-gp.

4.6 Fertility, pregnancy and lactation

Women of childbearing potential / contraception in males and females
When Sovaldi is used in combination with ribavirin or peginterferon alfa/ribavirin, extreme care must be taken to avoid pregnancy in female patients and in female partners of male patients. Significant teratogenic and/or embryocidal effects have been demonstrated in all animal species exposed to ribavirin (see section 4.4). Women of childbearing potential or their male partners must use an effective form of contraception during treatment and for a period of time after the treatment has concluded as recommended in the Summary of Product Characteristics for ribavirin. Refer to the Summary of Product Characteristics for ribavirin for additional information.

Pregnancy
There are no or limited amount of data (less than 300 pregnancy outcomes) from the use of sofosbuvir in pregnant women.

Animal studies do not indicate direct or indirect harmful effects with respect to reproductive toxicity. No effects on foetal development have been observed in rats and rabbits at the highest doses tested. However, it has not been possible to fully estimate exposure margins achieved for sofosbuvir in the rat relative to the exposure in humans at the recommended clinical dose (see section 5.3).

As a precautionary measure, it is preferable to avoid the use of Sovaldi during pregnancy.

However, if ribavirin is co-administered with sofosbuvir, the contraindications regarding use of ribavirin during pregnancy apply (see also the Summary of Product Characteristics for ribavirin).

Breast-feeding
It is unknown whether sofosbuvir and its metabolites are excreted in human milk.

Available pharmacokinetic data in animals has shown excretion of metabolites in milk (for details see section 5.3).

A risk to newborns/infants cannot be excluded. Therefore, Sovaldi should not be used during breast-feeding.

Fertility
No human data on the effect of Sovaldi on fertility are available. Animal studies do not indicate harmful effects on fertility.

4.7 Effects on ability to drive and use machines

Sovaldi has moderate influence on the ability to drive and use machines. Patients should be informed that fatigue and disturbance in attention, dizziness and blurred vision have been reported during treatment with sofosbuvir in combination with peginterferon alfa and ribavirin (see section 4.8).

4.8 Undesirable effects

Summary of the safety profile
During treatment with sofosbuvir in combination with ribavirin or with peginterferon alfa and ribavirin, the most frequently reported adverse drug reactions were consistent with the expected safety profile of ribavirin and peginterferon alfa treatment, without increasing the frequency or severity of the expected adverse drug reactions.

Assessment of adverse reactions is based on pooled data from five Phase 3 clinical studies (both controlled and uncontrolled).

The proportion of subjects who permanently discontinued treatment due to adverse reactions was 1.4% for subjects receiving placebo, 0.5% for subjects receiving sofosbuvir + ribavirin for 12 weeks, 0% for subjects receiving sofosbuvir + ribavirin for 16 weeks, 11.1% for subjects receiving peginterferon alfa + ribavirin for 24 weeks and 2.4% for subjects receiving sofosbuvir + peginterferon alfa + ribavirin for 12 weeks.

Tabulated summary of adverse reactions
Sovaldi has mainly been studied in combination with ribavirin, with or without peginterferon alfa. In this context, no adverse drug reactions specific to sofosbuvir have been identified. The most common adverse drug reactions occurring in subjects receiving sofosbuvir and ribavirin or sofosbuvir, ribavirin and peginterferon alfa were fatigue, headache, nausea and insomnia.

The following adverse drug reactions have been identified with sofosbuvir in combination with ribavirin or in combination with peginterferon alfa and ribavirin (Table 4). The adverse reactions are listed below by body system organ class and frequency. Frequencies are defined as follows: very common (≥1/10), common (≥1/100 to <1/10), uncommon (≥1/1,000 to <1/100), rare (≥1/10,000 to <1/1,000) or very rare (<1/10,000).

Table 4: Adverse drug reactions identified with sofosbuvir in combination with ribavirin or peginterferon alfa and ribavirin

Frequency	SOF[a] + RBV[b]	SOF + PEG[c] + RBV
Infections and infestations:		
Common	nasopharyngitis	
Blood and lymphatic system disorders:		
Very common	haemoglobin decreased	anaemia, neutropenia, lymphocyte count decreased, platelet count decreased
Common	anaemia	
Metabolism and nutrition disorders:		
Very common		decreased appetite
Common		weight decreased
Psychiatric disorders:		
Very common	insomnia	insomnia
Common	depression	depression, anxiety, agitation
Nervous system disorders:		
Very common	headache	dizziness, headache
Common	disturbance in attention	migraine, memory impairment, disturbance in attention
Eye disorders:		
Common		vision blurred
Respiratory, thoracic and mediastinal disorders:		
Very common		dyspnoea, cough
Common	dyspnoea, dyspnoea exertional, cough	dyspnoea exertional
Gastrointestinal disorders:		
Very common	nausea	diarrhoea, nausea, vomiting
Common	abdominal discomfort, constipation, dyspepsia	constipation, dry mouth, gastroesophageal reflux
Hepatobiliary disorders:		
Very common	blood bilirubin increased	blood bilirubin increased
Skin and subcutaneous tissue disorders:		
Very common		rash, pruritus
Common	alopecia, dry skin, pruritus	alopecia, dry skin
Musculoskeletal and connective tissue disorders:		
Very common		arthralgia, myalgia
Common	arthralgia, back pain, muscle spasms, myalgia	back pain, muscle spasms
General disorders and administration site conditions:		
Very common	fatigue, irritability	chills, fatigue, influenza-like illness, irritability, pain, pyrexia
Common	pyrexia, asthenia	chest pain, asthenia

a. SOF = sofosbuvir; b. RBV = ribavirin; c. PEG = peginterferon alfa.

Other special population(s)

HIV/HCV co-infection

The safety profile of sofosbuvir and ribavirin in HCV/HIV co-infected subjects was similar to that observed in mono-infected HCV subjects treated with sofosbuvir and ribavirin in Phase 3 clinical studies (see section 5.1).

Patients awaiting liver transplantation

The safety profile of sofosbuvir and ribavirin in HCV infected subjects prior to liver transplantation was similar to that observed in subjects treated with sofosbuvir and ribavirin in Phase 3 clinical studies (see section 5.1).

Reporting of suspected adverse reactions

Reporting suspected adverse reactions after authorisation of the medicinal product is important. It allows continued monitoring of the benefit/risk balance of the medicinal

product. Healthcare professionals are asked to report any suspected adverse reactions via the national reporting system listed in Appendix V.

4.9 Overdose

The highest documented dose of sofosbuvir was a single supratherapeutic dose of sofosbuvir 1,200 mg administered to 59 healthy subjects. In that study, there were no untoward effects observed at this dose level, and adverse reactions were similar in frequency and severity to those reported in the placebo and sofosbuvir 400 mg treatment groups. The effects of higher doses are unknown.

No specific antidote is available for overdose with Sovaldi. If overdose occurs the patient must be monitored for evidence of toxicity. Treatment of overdose with Sovaldi consists of general supportive measures including monitoring of vital signs as well as observation of the clinical status of the patient. Haemodialysis can efficiently remove (53% extraction ratio) the predominant circulating metabolite GS-331007. A 4-hour haemodialysis session removed 18% of the administered dose.

5. PHARMACOLOGICAL PROPERTIES

5.1 Pharmacodynamic properties

Pharmacotherapeutic group: Direct-acting antiviral; ATC code: not yet assigned

Mechanism of action
Sofosbuvir is a pan-genotypic inhibitor of the HCV NS5B RNA-dependent RNA polymerase, which is essential for viral replication. Sofosbuvir is a nucleotide prodrug that undergoes intracellular metabolism to form the pharmacologically active uridine analog triphosphate (GS-461203), which can be incorporated into HCV RNA by the NS5B polymerase and acts as a chain terminator. In a biochemical assay, GS-461203 inhibited the polymerase activity of the recombinant NS5B from HCV genotype 1b, 2a, 3a and 4a with a 50% inhibitory concentration (IC_{50}) value ranging from 0.7 to 2.6 μM. GS-461203 (the active metabolite of sofosbuvir) is not an inhibitor of human DNA and RNA polymerases nor an inhibitor of mitochondrial RNA polymerase.

Antiviral activity
In HCV replicon assays, the effective concentration (EC_{50}) values of sofosbuvir against full-length replicons from genotype 1a, 1b, 2a, 3a and 4a were 0.04, 0.11, 0.05, 0.05 and 0.04 μM, respectively, and EC_{50} values of sofosbuvir against chimeric 1b replicons encoding NS5B from genotype 2b, 5a or 6a were 0.014 to 0.015 μM. The mean ± SD EC_{50} of sofosbuvir against chimeric replicons encoding NS5B sequences from clinical isolates was 0.068 ± 0.024 μM for genotype 1a (n = 67), 0.11 ± 0.029 μM for genotype 1b (n = 29), 0.035 ± 0.018 μM for genotype 2 (n = 15) and 0.085 ± 0.034 μM for genotype 3a (n = 106). In these assays, the *in vitro* antiviral activity of sofosbuvir against the less common genotypes 4, 5 and 6 was similar to that observed for genotypes 1, 2 and 3.

The presence of 40% human serum had no effect on the anti-HCV activity of sofosbuvir.

Resistance
In cell culture
HCV replicons with reduced susceptibility to sofosbuvir have been selected in cell culture for multiple genotypes including 1b, 2a, 2b, 3a, 4a, 5a and 6a. Reduced susceptibility to sofosbuvir was associated with the primary NS5B substitution S282T in all replicon

genotypes examined. Site-directed mutagenesis of the S282T substitution in replicons of 8 genotypes conferred 2- to 18-fold reduced susceptibility to sofosbuvir and reduced the replication viral capacity by 89% to 99% compared to the corresponding wild-type. In biochemical assays, recombinant NS5B polymerase from genotypes 1b, 2a, 3a and 4a expressing the S282T substitution showed reduced susceptibility to GS-461203 compared to respective wild-types.

In clinical studies
In a pooled analysis of 991 subjects who received sofosbuvir in Phase 3 studies, 226 subjects qualified for resistance analysis due to virologic failure or early study drug discontinuation and having HCV RNA >1,000 IU/mL. Post-baseline NS5B sequences were available for 225 of the 226 subjects, with deep sequencing data (assay cutoff of 1%) from 221 of these subjects. The sofosbuvir-associated resistance substitution S282T was not detected in any of these subjects by deep sequencing or population sequencing. The S282T substitution in NS5B was detected in a single subject receiving Sovaldi monotherapy in a Phase 2 study. This subject harboured <1% HCV S282T at baseline and developed S282T (>99%) at 4 weeks post-treatment which resulted in a 13.5-fold change in sofosbuvir EC_{50} and reduced viral replication capacity. The S282T substitution reverted to wild-type over the next 8 weeks and was no longer detectable by deep sequencing at 12 weeks post-treatment.

Two NS5B substitutions, L159F and V321A, were detected in post-treatment relapse samples from multiple genotype 3 HCV infected subjects in the Phase 3 clinical studies. No shift in the phenotypic susceptibility to sofosbuvir or ribavirin of subject isolates with these substitutions was detected. In addition, S282R and L320F substitutions were detected on treatment by deep sequencing in a pre-transplant subject with a partial treatment response. The clinical significance of these findings is unknown.

Effect of baseline HCV polymorphisms on treatment outcome
Baseline NS5B sequences were obtained for 1,292 subjects from Phase 3 studies by population sequencing and the S282T substitution was not detected in any subject with available baseline sequence. In an analysis evaluating the effect of baseline polymorphisms on treatment outcome, no statistically significant association was observed between the presence of any HCV NS5B variant at baseline and treatment outcome.

Cross-resistance
HCV replicons expressing the sofosbuvir-associated resistance substitution S282T were fully susceptible to other classes of anti-HCV agents. Sofosbuvir retained activity against the NS5B substitutions L159F and L320F associated with resistance to other nucleoside inhibitors. Sofosbuvir was fully active against substitutions associated with resistance to other direct-acting antivirals with different mechanisms of actions, such as NS5B non-nucleoside inhibitors, NS3 protease inhibitors and NS5A inhibitors.

Clinical efficacy and safety
The efficacy of sofosbuvir was evaluated in five Phase 3 studies in a total of 1,568 subjects with genotypes 1 to 6 chronic hepatitis C. One study was conducted in treatment-naïve subjects with genotype 1, 4, 5 or 6 chronic hepatitis C in combination with peginterferon alfa 2a and ribavirin and the other four studies were conducted in subjects with genotype 2 or 3 chronic hepatitis C in combination with ribavirin including one in treatment-naïve subjects, one in interferon intolerant, ineligible or unwilling subjects, one in subjects previously treated with an interferon-based regimen, and one in all subjects irrespective of prior treatment history or ability to receive treatment with interferon. Subjects in these studies had compensated liver disease including cirrhosis. Sofosbuvir was administered at a dose of 400 mg once daily. The ribavirin dose was weight-based at 1,000-1,200 mg daily administered in two divided doses, and the peginterferon alfa 2a dose,

where applicable, was 180 µg per week. Treatment duration was fixed in each study and was not guided by subjects' HCV RNA levels (no response guided algorithm).

Plasma HCV RNA values were measured during the clinical studies using the COBAS TaqMan HCV test (version 2.0), for use with the High Pure System. The assay had a lower limit of quantification (LLOQ) of 25 IU/mL. Sustained virologic response (SVR) was the primary endpoint to determine the HCV cure rate for all studies which was defined as HCV RNA less than LLOQ at 12 weeks after the end of treatment (SVR12).

Clinical studies in subjects with genotype 1, 4, 5 and 6 chronic hepatitis C
Treatment-naïve subjects - NEUTRINO (study 110)
NEUTRINO was an open-label, single-arm study that evaluated 12 weeks of treatment with sofosbuvir in combination with peginterferon alfa 2a and ribavirin in treatment-naïve subjects with genotype 1, 4, 5 or 6 HCV infection.

Treated subjects (n = 327) had a median age of 54 years (range: 19 to 70); 64% of the subjects were male; 79% were White; 17% were Black; 14% were Hispanic or Latino; mean body mass index was 29 kg/m^2 (range: 18 to 56 kg/m^2); 78% had baseline HCV RNA greater than 6 $\log_{10}$ IU/mL; 17% had cirrhosis; 89% had HCV genotype 1 and 11% had HCV genotype 4, 5 or 6. Table 5 presents the response rates for the treatment group of sofosbuvir + peginterferon alfa + ribavirin.

Table 5: Response rates in study NEUTRINO

	SOF+PEG+RBV 12 weeks (n = 327)
Overall SVR12	91% (296/327)
Outcome for subjects without SVR12	
On-treatment virologic failure	0/327
Relapse[a]	9% (28/326)
Other[b]	1% (3/327)

a. The denominator for relapse is the number of subjects with HCV RNA <LLOQ at their last on-treatment assessment.
b. Other includes subjects who did not achieve SVR12 and did not meet virologic failure criteria (e.g., lost to follow-up).

Response rates for selected subgroups are presented in Table 6.

Table 6: SVR12 rates for selected subgroups in NEUTRINO

	SOF+PEG+RBV 12 weeks (n = 327)
Genotype	
Genotype 1	90% (262/292)
Genotype 4, 5 or 6	97% (34/35)
Cirrhosis	
No	93% (253/273)
Yes	80% (43/54)
Race	
Black	87% (47/54)
Non-Black	91% (249/273)

SVR12 rates were similarly high in subjects with baseline IL28B C/C allele [94/95 (99%)] and non-C/C (C/T or T/T) allele [202/232 (87%)].

27/28 patients with genotype 4 HCV achieved SVR12. A single subject with genotype 5 and all 6 subjects with genotype 6 HCV infection in this study achieved SVR12.

Clinical studies in subjects with genotype 2 and 3 chronic hepatitis C

Treatment-naïve adults - FISSION (study 1231)

FISSION was a randomised, open-label, active-controlled study that evaluated 12 weeks of treatment with sofosbuvir and ribavirin compared to 24 weeks of treatment with peginterferon alfa 2a and ribavirin in treatment-naïve subjects with genotype 2 or 3 HCV infection. The ribavirin doses used in the sofosbuvir + ribavirin and peginterferon alfa 2a + ribavirin arms were weight-based 1,000-1,200 mg/day and 800 mg/day regardless of weight, respectively. Subjects were randomised in a 1:1 ratio and stratified by cirrhosis (presence *versus* absence), HCV genotype (2 *versus* 3) and baseline HCV RNA level (<6 $\log_{10}$ IU/mL *versus* ≥6 $\log_{10}$ IU/mL). Subjects with genotype 2 or 3 HCV were enrolled in an approximately 1:3 ratio.

Treated subjects (n = 499) had a median age of 50 years (range: 19 to 77); 66% of the subjects were male; 87% were White; 3% were Black; 14% were Hispanic or Latino; mean body mass index was 28 kg/m^2 (range: 17 to 52 kg/m^2); 57% had baseline HCV RNA levels greater than 6 $\log_{10}$ IU/mL; 20% had cirrhosis; 72% had HCV genotype 3. Table 7 presents the response rates for the treatment groups of sofosbuvir + ribavirin and peginterferon alfa + ribavirin.

Table 7: Response rates in study FISSION

	SOF+RBV 12 weeks (n = 256)[a]	**PEG+RBV 24 weeks (n = 243)**
Overall SVR12	67% (171/256)	67% (162/243)
Genotype 2	95% (69/73)	78% (52/67)
Genotype 3	56% (102/183)	63% (110/176)
Outcome for subjects without SVR12		
On-treatment virologic failure	< 1% (1/256)	7% (18/243)
Relapse[b]	30% (76/252)	21% (46/217)
Other[c]	3% (8/256)	7% (17/243)

a. The efficacy analysis includes 3 subjects with recombinant genotype 2/1 HCV infection.
b. The denominator for relapse is the number of subjects with HCV RNA <LLOQ at their last on-treatment assessment.
c. Other includes subjects who did not achieve SVR12 and did not meet virologic failure criteria (e.g., lost to follow-up).

The difference in the overall SVR12 rates between sofosbuvir + ribavirin and peginterferon alfa + ribavirin treatment groups was 0.3% (95% confidence interval: -7.5% to 8.0%) and the study met the predefined non-inferiority criterion.

Response rates for subjects with cirrhosis at baseline are presented in Table 8 by HCV genotype.

Table 8: SVR12 rates by cirrhosis and genotype in study FISSION

	Genotype 2		**Genotype 3**	
	SOF+RBV 12 weeks (n = 73)[a]	**PEG+RBV 24 weeks (n = 67)**	**SOF+RBV 12 weeks (n = 183)**	**PEG+RBV 24 weeks (n = 176)**
Cirrhosis				
No	97% (59/61)	81% (44/54)	61% (89/145)	71% (99/139)
Yes	83% (10/12)	62% (8/13)	34% (13/38)	30% (11/37)

a. The efficacy analysis includes 3 subjects with recombinant genotype 2/1 HCV infection.

Interferon intolerant, ineligible or unwilling adults - POSITRON (study 107)
POSITRON was a randomised, double-blinded, placebo-controlled study that evaluated 12 weeks of treatment with sofosbuvir and ribavirin (n = 207) compared to placebo (n = 71) in subjects who are interferon intolerant, ineligible or unwilling. Subjects were randomised in 3:1 ratio and stratified by cirrhosis (presence *versus* absence).

Treated subjects (n = 278) had a median age of 54 years (range: 21 to 75); 54% of the subjects were male; 91% were White; 5% were Black; 11% were Hispanic or Latino; mean body mass index was 28 kg/m^2 (range: 18 to 53 kg/m^2); 70% had baseline HCV RNA levels greater than 6 $\log_{10}$ IU/mL; 16% had cirrhosis; 49% had HCV genotype 3. The proportions of subjects who were interferon intolerant, ineligible, or unwilling were 9%, 44%, and 47%, respectively. Most subjects had no prior HCV treatment (81.3%). Table 9 presents the response rates for the treatment groups of sofosbuvir + ribavirin and placebo.

Table 9: Response rates in study POSITRON

	SOF+RBV 12 weeks (n = 207)	**Placebo 12 weeks (n = 71)**
Overall SVR12	78% (161/207)	0/71
Genotype 2	93% (101/109)	0/34
Genotype 3	61% (60/98)	0/37
Outcome for subjects without SVR12		
On-treatment virologic failure	0/207	97% (69/71)
Relapse[a]	20% (42/205)	0/0
Other[b]	2% (4/207)	3% (2/71)

a. The denominator for relapse is the number of subjects with HCV RNA <LLOQ at their last on-treatment assessment.
b. Other includes subjects who did not achieve SVR12 and did not meet virologic failure criteria (e.g., lost to follow-up).

The SVR12 rate in the sofosbuvir + ribavirin treatment group was statistically significant when compared to placebo ($p < 0.001$).

Table 10 presents the subgroup analysis by genotype for cirrhosis and interferon classification.

Table 10: SVR12 rates for selected subgroups by genotype in POSITRON

	SOF+RBV 12 weeks	
	Genotype 2 (n = 109)	**Genotype 3 (n = 98)**
Cirrhosis		
No	92% (85/92)	68% (57/84)
Yes	94% (16/17)	21% (3/14)
Interferon classification		
Ineligible	88% (36/41)	70% (33/47)
Intolerant	100% (9/9)	50% (4/8)
Unwilling	95% (56/59)	53% (23/43)

Previously treated adults - FUSION (study 108)
FUSION was a randomised, double-blinded study that evaluated 12 or 16 weeks of treatment with sofosbuvir and ribavirin in subjects who did not achieve SVR with prior interferon-based treatment (relapsers and nonresponders). Subjects were randomised in a 1:1 ratio and stratified by cirrhosis (presence *versus* absence) and HCV genotype (2 *versus* 3).

Treated subjects (n = 201) had a median age of 56 years (range: 24 to 70); 70% of the subjects were male; 87% were White; 3% were Black; 9% were Hispanic or Latino; mean body mass index was 29 kg/m^2 (range: 19 to 44 kg/m^2); 73% had baseline HCV RNA levels greater than 6 $\log_{10}$ IU/mL; 34% had cirrhosis; 63% had HCV genotype 3; 75% were prior relapsers. Table 11 presents the response rates for the treatment groups of sofosbuvir + ribavirin for 12 weeks and 16 weeks.

Table 11: Response rates in study FUSION

	SOF+RBV 12 weeks (n = 103)[a]	**SOF+RBV 16 weeks (n = 98)[a]**
Overall SVR12	50% (51/103)	71% (70/98)
Genotype 2	82% (32/39)	89% (31/35)
Genotype 3	30% (19/64)	62% (39/63)
Outcome for subjects without SVR12		
On-treatment virologic failure	0/103	0/98
Relapse[b]	48% (49/103)	29% (28/98)
Other[c]	3% (3/103)	0/98

a. The efficacy analysis includes 6 subjects with recombinant genotype 2/1 HCV infection.
b. The denominator for relapse is the number of subjects with HCV RNA <LLOQ at their last on-treatment assessment.
c. Other includes subjects who did not achieve SVR12 and did not meet virologic failure criteria (e.g., lost to follow-up).

Table 12 presents the subgroup analysis by genotype for cirrhosis and response to prior HCV treatment.

Table 12: SVR12 rates for selected subgroups by genotype in study FUSION

	Genotype 2		**Genotype 3**	
	SOF+RBV 12 weeks (n = 39)	**SOF+RBV 16 weeks (n = 35)**	**SOF+RBV 12 weeks (n = 64)**	**SOF+RBV 16 weeks (n = 63)**
Cirrhosis				
No	90% (26/29)	92% (24/26)	37% (14/38)	63% (25/40)
Yes	60% (6/10)	78% (7/9)	19% (5/26)	61% (14/23)
Response to prior HCV treatment				
Relapser	86% (25/29)	89% (24/27)	31% (15/49)	65% (30/46)
Nonresponder	70% (7/10)	88% (7/8)	27% (4/15)	53% (9/17)

Treatment-naïve and previously treated adults - VALENCE (study 133)
VALENCE was a Phase 3 study that evaluated sofosbuvir in combination with weight-based ribavirin for the treatment of genotype 2 or 3 HCV infection in treatment-naïve subjects or subjects who did not achieve SVR with prior interferon-based treatment, including subjects with compensated cirrhosis. The study was designed as a direct comparison of sofosbuvir and ribavirin *versus* placebo for 12 weeks. However, based on emerging data, the study was unblinded and all HCV genotype 2 subjects continued to receive sofosbuvir and ribavirin for 12 weeks, whilst treatment for HCV genotype 3 subjects was extended to 24 weeks. Eleven HCV genotype 3 subjects had already completed treatment with sofosbuvir and ribavirin for 12 weeks at the time of the amendment.

Treated subjects (n = 419) had a median age of 51 years (range: 19 to 74); 60% of the subjects were male; median body mass index was 25 kg/m^2 (range: 17 to 44 kg/m^2); the mean baseline HCV RNA level was 6.4 $\log_{10}$ IU/mL; 21% had cirrhosis; 78% had HCV genotype 3; 65% were prior relapsers. Table 13 presents the response rates for the treatment groups of sofosbuvir + ribavirin for 12 weeks and 24 weeks.

Placebo recipients are not included in the tables since none achieved SVR12.

Table 13: Response rates in study VALENCE

	Genotype 2 SOF+RBV 12 weeks (n = 73)	**Genotype 3 SOF+RBV 12 weeks (n = 11)**	**Genotype 3 SOF+RBV 24 weeks (n = 250)**
Overall SVR12	93% (68/73)	27% (3/11)	84% (210/250)
Outcome for subjects without SVR12			
On-treatment virologic failure	0% (0/73)	0% (0/11)	0.4% (1/250)
Relapse[a]	7% (5/73)	55% (6/11)	14% (34/249)
Other[b]	0% (0/73)	18% (2/11)	2% (5/250)

a. The denominator for relapse is the number of subjects with HCV RNA <LLOQ at their last on-treatment assessment.
b. Other includes subjects who did not achieve SVR12 and did not meet virologic failure criteria (e.g., lost to follow-up).

Table 14 presents the subgroup analysis by genotype for cirrhosis and exposure to prior HCV treatment.

Table 14: SVR12 rates for selected subgroups by genotype in study VALENCE

	Genotype 2 SOF+RBV 12 weeks (n = 73)	**Genotype 3 SOF+RBV 24 weeks (n = 250)**
Treatment-naïve	97% (31/32)	93% (98/105)
Non-cirrhotic	97% (29/30)	94% (86/92)
Cirrhotic	100% (2/2)	92% (12/13)
Treatment-experienced	90% (37/41)	77% (112/145)
Non-cirrhotic	91% (30/33)	85% (85/100)
Cirrhotic	88% (7/8)	60% (27/45)

SVR12 to SVR24 concordance
The concordance between SVR12 and SVR24 (SVR 24 weeks after the end of the treatment) following treatment with sofosbuvir in combination with ribavirin or ribavirin and pegylated interferon demonstrates a positive predictive value of 99% and a negative predictive value of 99%.

Clinical efficacy and safety in special populations
HCV/HIV co-infected patients - PHOTON-1 (study 123)
Sofosbuvir was studied in an open-label clinical study evaluating the safety and efficacy of 12 or 24 weeks of treatment with sofosbuvir and ribavirin in subjects with genotype 1, 2 or 3 chronic hepatitis C co-infected with HIV-1. Genotype 2 and 3 subjects were either treatment-naïve or experienced, whereas genotype 1 subjects were naïve to prior treatment. Treatment duration was 12 weeks in treatment-naïve subjects with genotype 2 or 3 HCV infection, and 24 weeks in treatment-experienced subjects with genotype 3 HCV infection, as well as subjects with genotype 1 HCV infection. Subjects received 400 mg sofosbuvir and weight-based ribavirin (1,000 mg for subjects weighing <75 kg or 1,200 mg for subjects weighing ≥75 kg). Subjects were either not on antiretroviral therapy with a CD4+ cell count >500 cells/mm^3 or had virologically suppressed HIV-1 with a CD4+ cell count >200 cells/mm^3. 95% of patients received antiretroviral therapy at the time of enrolment. Preliminary SVR12 data are available for 210 subjects.

Table 15 presents the response rates by genotype and exposure to prior HCV treatment.

Table 15: Response rates in study PHOTON-1

	Genotype 2/3 treatment-naïve SOF+RBV 12 weeks (n = 68)	**Genotype 2/3 treatment-experienced SOF+RBV 24 weeks (n = 28)**	**Genotype 1 treatment-naïve SOF+RBV 24 weeks (n = 114)**
Overall SVR12	75% (51/68)	93% (26/28)	76% (87/114)
Outcome for subjects without SVR12			
On-treatment virologic failure	1% (1/68)	0/28	1% (1/114)
Relapse[a]	18% (12/67)	7% (2/28)	22% (25/113)
Other[b]	6% (4/68)	0/28	1% (1/114)

a. The denominator for relapse is the number of subjects with HCV RNA <LLOQ at their last on-treatment assessment.
b. Other includes subjects who did not achieve SVR12 and did not meet virologic failure criteria (e.g., lost to follow-up).

Table 16 presents the subgroup analysis by genotype for cirrhosis.

Table 16: SVR12 rates for selected subgroups by genotype in study PHOTON-1

	HCV genotype 2		**HCV genotype 3**	
	SOF+RBV 12 weeks TN (n = 26)	**SOF+RBV 24 weeks TE (n = 15)**	**SOF+RBV 12 weeks TN (n = 42)**	**SOF+RBV 24 weeks TE (n = 13)**
Overall	88% (23/26)	93% (14/15)	67% (28/42)	92% (12/13)
No cirrhosis	88% (22/25)	92% (12/13)	67% (24/36)	100% (8/8)
Cirrhosis	100% (1/1)	100% (2/2)	67% (4/6)	80% (4/5)

TN = treatment-naïve; TE = treatment-experienced.

Patients awaiting liver transplantation - Study 2025
Sofosbuvir was studied in HCV infected subjects prior to undergoing liver transplantation in an open-label clinical study evaluating the safety and efficacy of sofosbuvir and ribavirin administered pre-transplant to prevent post-transplant HCV reinfection. The primary endpoint of the study was post-transplant virologic response (pTVR, HCV RNA <LLOQ at 12 weeks post-transplant). HCV infected subjects, regardless of genotype, with hepatocellular carcinoma (HCC) meeting the MILAN criteria received 400 mg sofosbuvir and 1,000-1,200 mg ribavirin daily for a maximum of 24 weeks, subsequently amended to 48 weeks, or until the time of liver transplantation, whichever occurred first. An interim analysis was conducted on 61 subjects who received sofosbuvir and ribavirin; the majority of subjects had HCV genotype 1, 44 subjects were CPT class A and 17 subjects were CPT class B. Of these 61 subjects, 44 subjects underwent liver transplantation following up to 48 weeks of treatment with sofosbuvir and ribavirin; 41 had HCV RNA <LLOQ at the time of transplantation. The virologic response rates of the 41 subjects transplanted with HCV RNA <LLOQ is described in Table 17. Duration of viral suppression prior to transplantation was the most predictive factor for pTVR in those who were HCV RNA <LLOQ at the time of transplantation.

Table 17: Virologic response post-transplant in subjects with HCV RNA <LLOQ at the time of liver transplantation

	Week 12 post-transplant (pTVR)[b]
Virologic response in evaluable subjects[a]	23/37 (62%)

a. Evaluable subjects are defined as those who have reached the specified time point at the time of the interim analysis.
b. pTVR: post-transplant virologic response (HCV RNA <LLOQ at 12 weeks post-procedure).

In patients that discontinued therapy at 24 weeks, according to protocol, the relapse rate was 11/15.

Overview of outcomes by therapeutic regimen and treatment duration, a comparison across studies

The following tables (Table 18 to Table 21) present data from Phase 2 and Phase 3 studies relevant to the dosing to help clinicians determine the best regimen for individual patients.

Table 18: Outcomes by therapeutic regimen and treatment duration, a comparison across studies in genotype 1 HCV infection

Patient population (Study number/name)	Regimen/Duration	Subgroup	SVR12 rate % (n/N)
Treatment-naïve[a] (NEUTRINO)	SOF+PEG+RBV 12 weeks	Overall	90% (262/292)
		Genotype 1a	92% (206/225)
		Genotype 1b	83% (55/66)
		No cirrhosis	93% (253/273)
		Cirrhosis	80% (43/54)
Treatment-naïve and co-infected with HIV (PHOTON-1)	SOF+RBV 24 weeks	Overall	76% (87/114)
		Genotype 1a	82% (74/90)
		Genotype 1b	54% (13/24)
		No cirrhosis	77% (84/109)
		Cirrhosis	60% (3/5)
Treatment-naïve (QUANTUM[b] and 11-1-0258[b])	SOF+RBV 24 weeks	Overall[c]	65% (104/159)
		Genotype 1a[c]	69% (84/121)
		Genotype 1b[c]	53% (20/38)
		No cirrhosis[c]	68% (100/148)
		Cirrhosis[c]	36% (4/11)

n = number of subjects with SVR12 response; N = total number of subjects per group.
a. For previously treated patients with genotype 1 HCV infection, no data exists with the combination of sofosbuvir, peginterferon alfa and ribavirin. Consideration should be given to treating these patients, and potentially extending the duration of therapy with sofosbuvir, peginterferon alfa and ribavirin beyond 12 weeks and up to 24 weeks; especially for those subgroups who have one or more factors historically associated with lower response rates to interferon-based therapies (prior null response to peginterferon alfa and ribavirin therapy, advanced fibrosis/cirrhosis, high baseline viral concentrations, black race, IL28B non CC genotype).
b. These are exploratory or Phase 2 studies. The outcomes should be interpreted with caution, as subject numbers are small and SVR rates may be impacted by the selection of patients.
c. Summary data from both studies.

Table 19: Outcomes by therapeutic regimen and treatment duration, a comparison across studies in genotype 2 HCV infection

Patient population (Study number/name)	Regimen/Duration	Subgroup	SVR12 rate % (n/N)
Treatment-naïve (FISSION)	SOF+RBV 12 weeks	Overall	95% (69/73)
		No cirrhosis	97% (59/61)
		Cirrhosis	83% (10/12)
Interferon intolerant, ineligible or unwilling (POSITRON)	SOF+RBV 12 weeks	Overall	93% (101/109)
		No cirrhosis	92% (85/92)
		Cirrhosis	94% (16/17)
Treatment-experienced (FUSION)	SOF+RBV 12 weeks	Overall	82% (32/39)
		No cirrhosis	90% (26/29)
		Cirrhosis	60% (6/10)
Treatment-naïve (VALENCE)	SOF+RBV 12 weeks	Overall	97% (31/32)
		No cirrhosis	97% (29/30)
		Cirrhosis	100% (2/2)
Treatment-experienced (VALENCE)	SOF+RBV 12 weeks	Overall	90% (37/41)
		No cirrhosis	91% (30/33)
		Cirrhosis	88% (7/8)
Treatment-experienced (FUSION)	SOF+RBV 16 weeks	Overall	89% (31/35)
		No cirrhosis	92% (24/26)
		Cirrhosis	78% (7/9)
Treatment-naïve co-infected with HIV (PHOTON-1)	SOF+RBV 12 weeks	Overall	88% (23/26)
		No cirrhosis	88% (22/25)
		Cirrhosis	100% (1/1)
Treatment-experienced co-infected with HIV (PHOTON-1)	SOF+RBV 24 weeks	Overall[a]	93% (14/15)
		No cirrhosis[a]	92% (12/13)
		Cirrhosis[a]	100% (2/2)
Treatment-naïve (ELECTRON[b] and PROTON[b])	SOF+PEG+RBV 12 weeks	Overall[c]	96% (25/26)
Treatment-experienced (LONESTAR-2[b])	SOF+PEG+RBV 12 weeks	Overall	96% (22/23)
		No cirrhosis	100% (9/9)
		Cirrhosis	93% (13/14)

n = number of subjects with SVR12 response; N = total number of subjects per group.
a. These data are preliminary.
b. These are exploratory or Phase 2 studies. The outcomes should be interpreted with caution, as subject numbers are small and SVR rates may be impacted by the selection of patients. In the ELECTRON study (N = 11), the duration of peginterferon alfa ranged from 4-12 weeks in combination with sofosbuvir + ribavirin.
c. All patients were non-cirrhotic in these two studies.

Table 20: Outcomes by therapeutic regimen and treatment duration, a comparison across studies in genotype 3 HCV infection

Patient population (Study number/name)	Regimen/Duration	Subgroup	SVR12 rate % (n/N)
Treatment-naïve (FISSION)	SOF+RBV 12 weeks	Overall	56% (102/183)
		No cirrhosis	61% (89/145)
		Cirrhosis	34% (13/38)
Interferon intolerant, ineligible or unwilling (POSITRON)	SOF+RBV 12 weeks	Overall	61% (60/98)
		No cirrhosis	68% (57/84)
		Cirrhosis	21% (3/14)
Treatment-experienced (FUSION)	SOF+RBV 12 weeks	Overall	30% (19/64)
		No cirrhosis	37% (14/38)
		Cirrhosis	19% (5/26)
Treatment-experienced (FUSION)	SOF+RBV 16 weeks	Overall	62% (39/63)
		No cirrhosis	63% (25/40)
		Cirrhosis	61% (14/23)
Treatment-naïve (VALENCE)	SOF+RBV 24 weeks	Overall	93% (98/105)
		No cirrhosis	94% (86/92)
		Cirrhosis	92% (12/13)
Treatment-experienced (VALENCE)	SOF+RBV 24 weeks	Overall	77% (112/145)
		No cirrhosis	85% (85/100)
		Cirrhosis	60% (27/45)
Treatment-naïve co-infected with HIV (PHOTON-1)	SOF+RBV 12 weeks	Overall	67% (28/42)
		No cirrhosis	67% (24/36)
		Cirrhosis	67% (4/6)
Treatment-experienced co-infected with HIV (PHOTON-1)	SOF+RBV 24 weeks	Overall[a]	92% (12/13)
		No cirrhosis[a]	100% (8/8)
		Cirrhosis[a]	80% (4/5)
Treatment-naïve (ELECTRON[b] and PROTON[b])	SOF+PEG+RBV 12 weeks	Overall[c]	97% (38/39)
Treatment-experienced (LONESTAR-2[b])	SOF+PEG+RBV 12 weeks	Overall	83% (20/24)
		No cirrhosis	83% (10/12)
		Cirrhosis	83% (10/12)

n = number of subjects with SVR12 response; N = total number of subjects per group.
a. These data are preliminary.
b. These are exploratory or Phase 2 studies. The outcomes should be interpreted with caution, as subject numbers are small and SVR rates may be impacted by the selection of patients. In the ELECTRON study (N = 11), the duration of peginterferon alfa ranged from 4-12 weeks in combination with sofosbuvir + ribavirin.
c. All patients were non-cirrhotic in these two studies.

Table 21: Outcomes by therapeutic regimen and treatment duration, a comparison across studies in genotype 4, 5 and 6 HCV infection

Patient population (Study number/name)	Regimen/Duration	Subgroup	SVR12 rate % (n/N)
Treatment-naïve (NEUTRINO)	SOF+PEG+RBV 12 weeks	Overall	97% (34/35)
		No cirrhosis	100% (33/33)
		Cirrhosis	50% (1/2)

n = number of subjects with SVR12 response; N = total number of subjects per group.

Paediatric population

The European Medicines Agency has deferred the obligation to submit the results of studies with sofosbuvir in one or more subsets of the paediatric populations in the treatment of chronic hepatitis C (see section 4.2 for information on paediatric use).

5.2 Pharmacokinetic properties

Sofosbuvir is a nucleotide prodrug that is extensively metabolised. The active metabolite is not observed. The predominant (>90%) metabolite, GS-331007, is inactive. It is formed through sequential and parallel pathways to the formation of active metabolite.

Absorption

The pharmacokinetic properties of sofosbuvir and the predominant circulating metabolite GS-331007 have been evaluated in healthy adult subjects and in subjects with chronic hepatitis C. Following oral administration, sofosbuvir was absorbed quickly and the peak plasma concentration was observed ~0.5-2 hour post-dose, regardless of dose level. Peak plasma concentration of GS-331007 was observed between 2 to 4 hours post-dose. Based on population pharmacokinetic analysis in subjects with genotypes 1 to 6 HCV infection (n = 986), steady-state AUC_{0-24} for sofosbuvir and GS-331007 was 1,010 ng•h/mL and 7,200 ng•h/mL, respectively. Relative to healthy subjects (n = 284), the sofosbuvir and GS-331007 AUC_{0-24} was 57% higher and 39% lower, respectively in HCV infected subjects.

Effects of food

Relative to fasting conditions, the administration of a single dose of sofosbuvir with a standardised high fat meal slowed the rate of absorption of sofosbuvir. The extent of absorption of sofosbuvir was increased approximately 1.8-fold, with little effect on peak concentration. The exposure to GS-331007 was not altered in the presence of a high-fat meal.

Distribution

Sofosbuvir is not a substrate for hepatic transporters including the organic anion-transporting polypeptide (OATP) 1B1 or 1B3. While subject to active tubular secretion, GS-331007 is not a substrate for renal transporters including organic anion transporter (OAT) 1 or 3, or organic cation transporter (OCT) 2.

Sofosbuvir is approximately 85% bound to human plasma proteins (*ex vivo* data) and the binding is independent of drug concentration over the range of 1 μg/mL to 20 μg/mL. Protein binding of GS-331007 was minimal in human plasma. After a single 400 mg dose of [^{14}C]-sofosbuvir in healthy subjects, the blood to plasma ratio of ^{14}C-radioactivity was approximately 0.7.

Biotransformation

Sofosbuvir is extensively metabolised in the liver to form the pharmacologically active nucleoside analog triphosphate GS-461203. The metabolic activation pathway involves sequential hydrolysis of the carboxyl ester moiety catalysed by human cathepsin A (CatA) or carboxylesterase 1 (CES1) and phosphoramidate cleavage by histidine triad nucleotide-binding protein 1 (HINT1) followed by phosphorylation by the pyrimidine nucleotide biosynthesis pathway. Dephosphorylation results in the formation of nucleoside metabolite GS-331007 that cannot be efficiently rephosphorylated and lacks anti-HCV activity *in vitro*.

After a single 400 mg oral dose of [^{14}C]-sofosbuvir, sofosbuvir and GS-331007 accounted for approximately 4% and >90% of drug-related material (sum of molecular weight-adjusted AUC of sofosbuvir and its metabolites) systemic exposure, respectively.

Elimination

Following a single 400 mg oral dose of [^{14}C]-sofosbuvir, mean total recovery of the dose was greater than 92%, consisting of approximately 80%, 14%, and 2.5% recovered in urine, faeces, and expired air, respectively. The majority of the sofosbuvir dose recovered in urine was GS-331007 (78%) while 3.5% was recovered as sofosbuvir. This data indicate that renal clearance is the major elimination pathway for GS-331007 with a large part actively secreted. The median terminal half-lives of sofosbuvir and GS-331007 were 0.4 and 27 hours respectively.

Linearity/non-linearity
The dose linearity of sofosbuvir and its primary metabolite, GS-331007, was evaluated in fasted healthy subjects. Sofosbuvir and GS-331007 AUCs are near dose proportional over the dose range of 200 mg to 400 mg.

Pharmacokinetics in special populations
Gender and race
No clinically relevant pharmacokinetic differences due to gender or race have been identified for sofosbuvir and GS-331007.

Elderly
Population pharmacokinetic analysis in HCV infected subjects showed that within the age range (19 to 75 years) analysed, age did not have a clinically relevant effect on the exposure to sofosbuvir and GS-331007. Clinical studies of sofosbuvir included 65 subjects aged 65 and over. The response rates observed for subjects over 65 years of age were similar to that of younger subjects across treatment groups.

Renal impairment
The pharmacokinetics of sofosbuvir were studied in HCV negative subjects with mild (eGFR ≥50 and <80 mL/min/1.73 m^2), moderate (eGFR ≥30 and <50 mL/min/1.73 m^2), severe renal impairment (eGFR <30 mL/min/1.73 m^2) and subjects with ESRD requiring haemodialysis following a single 400 mg dose of sofosbuvir. Relative to subjects with normal renal function (eGFR >80 mL/min/1.73 m^2), the sofosbuvir $AUC_{0\text{-inf}}$ was 61%, 107% and 171% higher in mild, moderate and severe renal impairment, while the GS-331007 $AUC_{0\text{-inf}}$ was 55%, 88% and 451% higher, respectively. In subjects with ESRD, relative to subjects with normal renal function, sofosbuvir $AUC_{0\text{-inf}}$ was 28% higher when sofosbuvir was dosed 1 hour before haemodialysis compared with 60% higher when sofosbuvir was dosed 1 hour after haemodialysis. The $AUC_{0\text{-inf}}$ of GS-331007 in subjects with ESRD could not be reliably determined. However, data indicate at least 10-fold and 20-fold higher exposure to GS-331007 in ESRD compared to normal subjects when Sovaldi was administered 1 hour before or 1 hour after haemodialysis, respectively.

Haemodialysis can efficiently remove (53% extraction ratio) the predominant circulating metabolite GS-331007. A 4-hour haemodialysis session removed approximately 18% of administered dose. No dose adjustment is required for patients with mild or moderate renal impairment. The safety of Sovaldi has not been assessed in patients with severe renal impairment or ESRD (see section 4.4).

Hepatic impairment
The pharmacokinetics of sofosbuvir were studied following 7-day dosing of 400 mg sofosbuvir in HCV infected subjects with moderate and severe hepatic impairment (CPT class B and C). Relative to subjects with normal hepatic function, the sofosbuvir $AUC_{0\text{-}24}$ was 126% and 143% higher in moderate and severe hepatic impairment, while the GS-331007 $AUC_{0\text{-}24}$ was 18% and 9% higher, respectively. Population pharmacokinetics analysis in HCV infected subjects indicated that cirrhosis had no clinically relevant effect on the exposure to sofosbuvir and GS-331007. No dose adjustment of sofosbuvir is recommended for patients with mild, moderate and severe hepatic impairment (see section 4.2).

Paediatric population
The pharmacokinetics of sofosbuvir and GS-331007 in paediatric subjects have not been established (see section 4.2).

Pharmacokinetic/pharmacodynamic relationship(s)

Efficacy, in terms of rapid virologic response, has been shown to correlate with exposure to sofosbuvir as well as GS 331007. However, neither of these entities has been evidenced to be a general surrogate marker for efficacy (SVR12) at the therapeutic 400 mg dose.

5.3 Preclinical safety data

In repeat dose toxicology studies in rat and dog, high doses of the 1:1 diastereomeric mixture caused adverse liver (dog) and heart (rat) effects and gastrointestinal reactions (dog). Exposure to sofosbuvir in rodent studies could not be detected likely due to high esterase activity; however, exposure to the major metabolite GS-331007 at the adverse dose was 29 times (rat) and 123 times (dog) higher than the clinical exposure at 400 mg sofosbuvir. No liver or heart findings were observed in chronic toxicity studies at exposures 9 times (rat) and 27 times (dog) higher than the clinical exposure.

Sofosbuvir was not genotoxic in a battery of *in vitro* or *in vivo* assays, including bacterial mutagenicity, chromosome aberration using human peripheral blood lymphocytes and *in vivo* mouse micronucleus assays.

Carcinogenicity studies in mice and rats do not indicate any carcinogenicity potential of sofosbuvir administered at doses up to 600 mg/kg/day in mouse and 750 mg/kg/day in rat. Exposure to GS-331007 in these studies was up to 30 times (mouse) and 15 times (rat) higher than the clinical exposure at 400 mg sofosbuvir.

Sofosbuvir had no effects on embryo-foetal viability or on fertility in rat and was not teratogenic in rat and rabbit development studies. No adverse effects on behaviour, reproduction or development of offspring in rat were reported. In rabbit studies exposure to sofosbuvir was 9 times the expected clinical exposure. In the rat studies, exposure to sofosbuvir could not be determined but exposure margins based on the major human metabolite ranged from 8 to 28 times higher than the clinical exposure at 400 mg sofosbuvir.

Sofosbuvir-derived material was transferred through the placenta in pregnant rats and into the milk of lactating rats.

6. PHARMACEUTICAL PARTICULARS

6.1 List of excipients

<u>Tablet core</u>
Mannitol (E421)
Microcrystalline cellulose (E460(i))
Croscarmellose sodium
Colloidal anhydrous silica (E551)
Magnesium stearate (E470b)

<u>Film-coating</u>
Polyvinyl alcohol (E1203)
Titanium dioxide (E171)
Macrogol 3350 (E1521)
Talc (E553b)
Yellow iron oxide (E172)

6.2 Incompatibilities

Not applicable.

6.3 Shelf life

2 years.

6.4 Special precautions for storage

This medicinal product does not require any special storage conditions.

6.5 Nature and contents of container

Sovaldi tablets are supplied in high density polyethylene (HDPE) bottles with a polypropylene child-resistant closure containing 28 film-coated tablets with a silica gel desiccant and polyester coil.

The following pack sizes are available: outer cartons containing 1 bottle of 28 film-coated tablets and outer cartons containing 84 (3 bottles of 28) film-coated tablets.

Not all pack sizes may be marketed.

6.6 Special precautions for disposal

Any unused medicinal product or waste material should be disposed of in accordance with local requirements.

7. MARKETING AUTHORISATION HOLDER

Gilead Sciences International Ltd.
Cambridge
CB21 6GT
United Kingdom

8. MARKETING AUTHORISATION NUMBER(S)

EU/0/00/000/000
EU/0/00/000/000

9. DATE OF FIRST AUTHORISATION/RENEWAL OF THE AUTHORISATION

Date of first authorisation:

10. DATE OF REVISION OF THE TEXT

Detailed information on this medicinal product is available on the website of the European Medicines Agency http://www.ema.europa.eu

Additional analysis for HCV/HIV co-infected patients

It should be noted that for the HCV/HIV co-infection population, separate economic results were not included in the main economic analysis presented in section **Error! Reference source not found.**. This is because as per the label it is anticipated that this population responds in a similar manner to sofosbuvir-based regimens in the mono-infected population with respect to safety and efficacy (see section **Error! Reference source not found.** for more details).

In the interests of providing full information for NICE, please find details of the treatment regimens (Table 1) and the ICERs for sofosbuvir against each comparator relating to the HIV co-infected population (Table 2). Additionally, the ICERs for current available treatment against the least expensive comparator in each indication, as well as incremental analysis are presented in Table 3 to Table 7

Table 1 Intervention considered for HCV/HIV co-infected patients

Genotype 1		
GT1 TN HCV/HIV co-infected	SOF (400 mg OD) + weight-based RBV (1,000-1,200 mg OD) for 24 weeks	PEG-IFN-2a (180 µg/wk) + weight-based RBV (15 mg/kg OD) for 48 weeks NT
Genotype 2		
GT2 TN HCV/HIV co-infected	SOF (400 mg OD) + weight-based RBV (1,000-1,200 mg OD) for 12 weeks	PEG-IFN-2a (180 µg/wk) + weight-based RBV (15 mg/kg OD) for 48 weeks
GT2 TE HCV/HIV co-infected	SOF (400 mg OD) + weight-based RBV (1,000-1,200 mg OD) for 24 weeks	PEG-IFN-2a (180 µg/wk) + weight-based RBV (15 mg/kg OD) for 48 weeks NT
Genotype 3		
GT3 TN HCV/HIV co-infected	SOF (400 mg OD) + weight-based RBV (1,000-1,200 mg OD) for 12 weeks	PEG-IFN-2a (180 µg/wk) + weight-based RBV (15 mg/kg OD) for 48 weeks
GT3 TE HCV/HIV co-infected	SOF (400 mg OD) + weight-based RBV (1,000-1,200 mg OD) for 24 weeks	PEG-IFN-2a (180 µg/wk) + weight-based RBV (15 mg/kg OD) for 48 weeks

µg: micrograms; GT: Genotype; mg: Milligrams; NT: No treatment; PEG-IFN-2a: PEG-IFN-interferon 2a; OD: Once daily; RBV: Ribavirin; SOF: Sofosbuvir; weeks: weeks; q8h: every 8 hours; TE: Treatment-experienced; TN: Treatment-naïve; kg: Kilogram
Weight-based RBV: if average weight less or equal to 75 kg then 1000 mg/day; otherwise; 1200 mg/day

Table 2 Summary of base-case cost-effectiveness results for HCV/HIV co-infection (ICER for sofosbuvir against each comparator: £/QALY)

Indication	Sofosbuvir regimen	Comparator	
		No treatment	PEG-IFN2a+RBV
GT1			
TN HCV/HIV co-infected	SOF+RBV 24 wks	£28,504	£43,836
GT2			
TN HCV/HIV co-infected	SOF+RBV 12 wks	-	£55,867
TE HCV/HIV co-infected	SOF+RBV 24 wks	£10,572	£128,248
GT3			
TN HCV/HIV co-infected	SOF+RBV 12 wks	-	Dominated
TE HCV/HIV co-infected	SOF+RBV 24 wks	£10,646	£90,822

Genotype 1 treatment-naïve HCV/HIV co-infected

While SOF + RBV is cost-effective against no treatment (for a £30,000/QALY threshold) it is just over £40,000/QALY when compared to PEG-IFN + RBV (Table 2). It is important to note that the SVR rates for PEG-IFN (from the PERICO trial) were not split between non-cirrhotic and cirrhotic patients. In the model it was assumed that the 35% SVR rate was for a non-cirrhotic population. However, in the PERICO trial 49% of patients had advanced liver fibrosis. Therefore caution should be taken when interpreting the model results.

No comparison against a PI regimen was included in the analysis. According to the recently approved BHIVA co-infection guidelines PI use is recommended in cirrhotic patients or when patients request to be treated. For non-cirrhotic patients treatment should be undertaken for 48 weeks [359]. Recent data from three real world cohorts of HCV/HIV patients presented at AASLD showed SVR rates of 47-61% and high rates of premature discontinuation with triple-therapy [360-362]. These are lower than the SVR rates for sofosbuvir obtained from the PHOTON-1 trial (77% and 60% for non-cirrhotic and cirrhotic patients, respectively). In addition adverse events were almost absent and treatment is only administered for 24 weeks. Finally the BHIVA co-infection guidelines suggest that, whenever possible, patients with non-cirrhotic disease should defer treatment until newer agents are available [359].

Genotype 2 treatment-naïve HCV/HIV co-infected

For genotype 2 treatment-naïve HCV/HIV the sofosbuvir is not cost-effective against PEG-IFN + RBV (Table 2). This may be related with the SVR rates for non-cirrhotic and cirrhotic patients on PEG-IFN + RBV. As mentioned previously caution should be taken when interpreting these results since the PERICO trial did not provide SVR rates for non-cirrhotic and cirrhotic patients, separately. Furthermore, these SVR rates are for GT2 and GT3 patients combined.

Genotype 2 treatment-experienced HCV/HIV co-infected

SOF + RBV is a cost-effective regimen against no treatment for genotype 2 treatment-experienced HCV/HIV co-infected patients (below the £20,000/QALY threshold). In contrast, the ICER is very high against PEG-IFN + RBV (£128,248/QALY, Table 2). This is due to the SVR rates used for PEG-IFN + RBV, which were assumed to be the same as those for treatment-naïve patients. This is considered to be a big limitation since a significant difference has been observed for the SVR rates between treatment-naïve and treatment-experienced in mono-infected patients. However, at the time of the analysis no publication was found that provided efficacy data on treatment-experienced HCV/HIV co-infected patients.

Genotype 3 treatment-naïve HCV/HIV co-infected

For genotype 3 treatment-naïve HCV/HIV sofosbuvir is dominated by PEG-IFN-2a (Table 2). The reason is that the SVR rate for non-cirrhotic patients on sofosbuvir is lower (67%) than for patients on PEG-IFN-2a + RBV (86%). As mentioned previously caution should be taken when interpreting these results since the PERICO trial did not provide SVR rates for non-cirrhotic and cirrhotic patients, separately, and the SVR rate was assumed for the non-cirrhotic cohort only. Furthermore, the SVR rate for sofosbuvir is based on a 12 weeks regimen, rather than a 24 weeks regimen which is recommended in the label for GT3 patients. Mono-infected and HIV co-infected patients have a similar response to sofosbuvir. It is expected that a 24 weeks regimen would originate higher SVR rates since evidence from the VALENCE

trial suggested a significant increase in SVR for the mono-infected population versus the original 12-week trial results from FISSION.

Genotype 3 treatment-experienced HCV/HIV co-infected

Please see explanation provided for the ICERs for genotype 2 treatment-experienced HCV/HIV co-infected.

Table 3 Cost-effectiveness results, GT1 TN HCV/HIV co-infected

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
No treatment	£22,473	18.4	12.6	NA	NA	NA	NA	NA
PEG-IFN-2a+RBV (48 wks)	£27,141	19.1	13.4	£4,669	0.7	0.8	£5,846	£5,846
SOF+RBV (24 wks)	£78,883	19.8	14.6	£56,411	1.4	2.0	£28,504	£43,836

Table 4 Cost-effectiveness results, GT2 TN HCV/HIV co-infected

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
PEG-IFN-2a+RBV (48 wks)	£20,303	19.8	12.8	NA	NA	NA	NA	NA
SOF+RBV (12 wks)	£41,380	20.2	13.2	£21,078	0.4	0.4	£55,867	£55,867

Table 5 Cost-effectiveness results, GT2 TE HCV/HIV co-infected

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
PEG-IFN-2a+RBV (48 wks)	£19,485	19.8	12.9	NA	NA	NA	NA	NA
No treatment	£32,031	17.0	9.1	£12,546	-2.7	-3.7	Dominated	Dominated
SOF+RBV (24 wks)	£76,280	20.3	13.3	£56,795	0.5	0.4	£128,248	£128,248

Table 6 Cost-effectiveness results, GT3 TN HCV/HIV co-infected

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
PEG-IFN-2a+RBV (48 wks)	£21,571	19.7	12.4	NA	NA	NA	NA	NA

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
SOF+RBV (12 wks)	£49,904	19.2	11.8	£28,333	-0.4	-0.6	Dominated	Dominated

Table 7 Cost-effectiveness results, GT3 TE HCV/HIV co-infected

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
PEG-IFN-2a+RBV (48 wks)	£20,686	19.7	12.5	NA	NA	NA	NA	NA
No treatment	£33,176	16.8	8.9	£12,491	-2.8	-3.6	Dominated	Dominated
SOF+RBV (24 wks)	£78,399	20.2	13.1	£57,713	0.5	0.6	£90,822	£90,822

10.1.1 Additional analysis using efficacy data from the MTC

A systematic review was also conducted to assess the feasibility of deriving comparative efficacy data (SVR rates) for use in the economic model through a MTC. Whilst we attempted to conduct a MTC for this analysis the results could not be considered robust (as discussed below) and it was considered most appropriate to populate the economic base case with efficacy data from individual studies in all patient groups. The data sources and rationale for these are described further in section **Error! Reference source not found.**.

- Due to the absence of data a MTC network could not be formed for all the populations of interest (i.e. GT 2/3 TE, GT 4/5/6 TN and IFN unsuitable patients)
- For patient groups where an MTC was feasible (TN IFN eligible patients with GT1, GT2 or GT3 infection), these analyses had several limitations
  - The structure of the HE model required that efficacy data were split out by cirrhotic and non-cirrhotic status. It was not possible to gain this split from all the comparator data available. In particular it was not possible to carry out meta-regressions and subgroup analyses distinguishing between genotype 2 and 3 and cirrhotic status simultaneously. It was also only feasible to run these analyses on a very small network thus rending non-robust results
  - In GT1 patients, a network including sofosbuvir was only possible by linking two small phase II trials (i.e. ATOMIC and PROTON) which included only non-cirrhotic patients
  - In addition assumptions had to be made to be able to link the two phase II trials. Since sofosbuvir phase II trials included only non-cirrhotic patients, we had to combine these data with the rest of the literature where the reported results were based on a combination of cirrhotic and non-cirrhotic patients. For this reason, the meta-regression carried out to provide separate results based on the cirrhotic status of patients did exclude sofosbuvir. A meta-regression was attempted to derive estimates for non-cirrhotic and cirrhotic patients. However, the network on which this analysis was based could not include sofosbuvir, limiting the utility of the GT1 MTC results as inputs for the cost-effectiveness model
  - In GT2 and GT3 patients the MTC results were based on those obtained for non-cirrhotic and cirrhotic patients combined (i.e. no separate cirrhotic or NC data available) as the split by both genotype (GT2 and GT3 respectively) and cirrhotic status was not available in the literature. A meta-regression was subsequently conducted to obtain the results for non-cirrhotic and cirrhotic patients separately. However, the results from the meta-regression were for GT2 and 3 combined. To obtain the results for non-cirrhotic and cirrhotic patients split by genotype the following assumptions had to be made: 1) That the meta-analysis results for GT2 and GT3 combined patients were considered for non-cirrhotic patients; 2) The odds ratio between non-cirrhotic and cirrhotic, obtained from the meta-regression for GT2 and 3 combined, was applied to the previous MTC results to obtain the results for cirrhotic patients. Therefore any results obtained are to be used with caution given the fact that the results of two meta-analyses had to be combined to estimate them
  - One major limitation of using the results of the MTC for GT3 is that the

treatment regimen included in the network (12 weeks of SOF+RBV) is no longer the licensed regimen for this indication (i.e. SOF+PEG-IFN+RBV for 12 weeks or SOF+RBV for 24 weeks)

The efficacy data obtained from the MTC

Table 8 SVR data obtained from the MTC

Non-cirrhotic and cirrhotic patients	Strategy	SVR	Odds ratio
GT1 TN IFN eligible[a]			
Non-cirrhotic and cirrhotic	SOF+PEG-IFN-2a+RBV (12 weeks)	84.9%[b]	6.55
	PEG-IFN-2a+RBV (48 weeks) (reference SVR)	46.2%	1.00
	Telaprevir+PEG-IFN-2a+RBV	76.5%[b]	3.80
	Boceprevir+PEG-IFN-2b+RBV	69.7%[b]	2.67
GT2 TN IFN eligible[c]			
Non-cirrhotic	SOF+RBV (12 weeks)	98.6%[b]	11.46
	PEG-IFN-2a+RBV (24 weeks) (reference SVR)	85.6%	1.00
Cirrhotic	SOF+RBV (12 weeks)	97.5%[b]	18.48
	PEG-IFN-2a+RBV (24 weeks) (reference SVR)	67.5%	1
GT3 TN IFN eligible[c]			
Non-cirrhotic	SOF+RBV (12 weeks)	62%[b]	0.76
	PEG-IFN-2a+RBV (24 weeks) (reference SVR)	68.3%	1.00
Cirrhotic	SOF+RBV (12 weeks)	47.8%[b]	1.22
	PEG-IFN-2a+RBV (24 weeks) (reference SVR)	42.8%	1.00

GT, Genotype; RBV, Ribavirin; SOF, Sofosbuvir; PEG-IFN-2a, Pegylated interferon α-2a; PEG-IFN-2b, Pegylated interferon α-2b; SVR, Sustained virological response; TN, Treatment-naïve

[a] The SVRs directly collected from the publications were used in the base case (rather than those obtained from the meta-analysis). The reason was that the base case results obtained from the meta-analysis did not split between non-cirrhotic and cirrhotic. Although meta-regression was also conducted this split was only obtained for PEG-IFN-2a, PEG-IFN-2b, telaprevir and boceprevir since the sofosbuvir trials could not be linked to the network.

[b] Calculation

[c] The SVRs directly collected from the publications were used in the base case (rather than those obtained from the meta-analysis). The reason was that several assumptions had to be made to obtain the SVR distributions split between non-cirrhotic and cirrhotic from the meta-analysis. More specifically, the meta-analysis provided the SVR distributions for the different treatments in GT2 or GT3 only. However, these distributions were for non-cirrhotic and cirrhotic patients combined. A meta-regression was conducted to get the odd ratios for cirrhotic versus non-cirrhotic in GT2 and GT3 patients combined. It was therefore assumed that the results from the meta-analysis for GT2 or GT3 alone were for non-cirrhotic patients. Then, the odd ratios between non-cirrhotic and cirrhotic were then applied to obtain the SVRs for cirrhotic patients in GT2 or GT3.

Results for genotype 1 treatment-naïve interferon eligible

Table 9 Cost-effectiveness results, GT1 TN IFN eligible using data from the MTC

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
PEG-IFN-2a+RBV (48 wks)	£23,185	19.6	14.0	NA	NA	NA	NA	NA
Boceprevir+PEG-IFN-2b+RBV	£37,639	20.0	14.6	£14,454	0.4	0.6	£24,513	Extended dominance
Telaprevir+PEG-IFN-2a+RBV	£37,700	20.1	14.8	£14,515	0.5	0.7	£19,422	£19,422
SOF+PEG-IFN-2a+RBV (12 wks)	£44,501	20.2	15.0	£21,316	0.6	1.0	£21,739	£29,162

Figure 1 Tornado diagram for SOF+PEG-IFN-2a+RBV (12 weeks) versus PEG-IFN-2a+RBV (48 weeks) in GT1 TN IFN eligible using data from the MTC

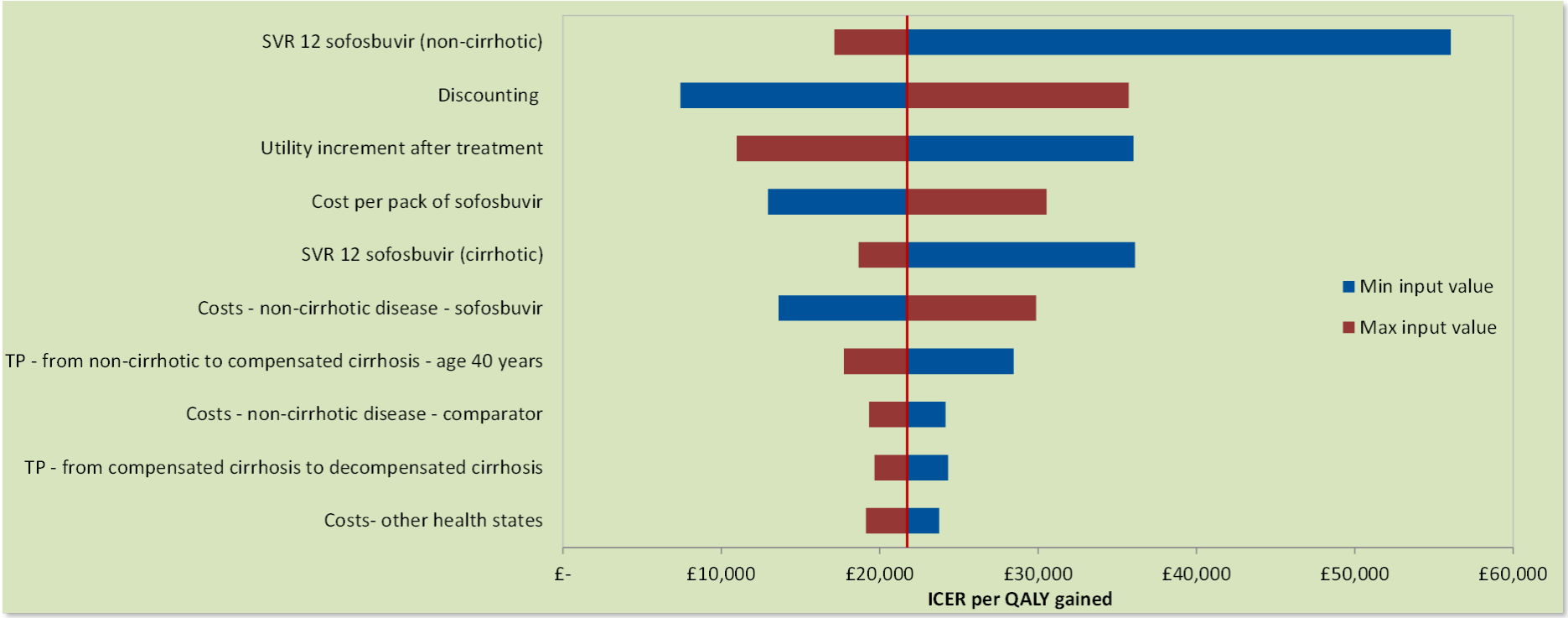


Figure 2 Tornado diagram for SOF+PEG-IFN+RBV (12 weeks) versus Boceprevir+PEG-IFN-2b+RBV (48 weeks) in GT1 TN IFN eligible using data from the MTC

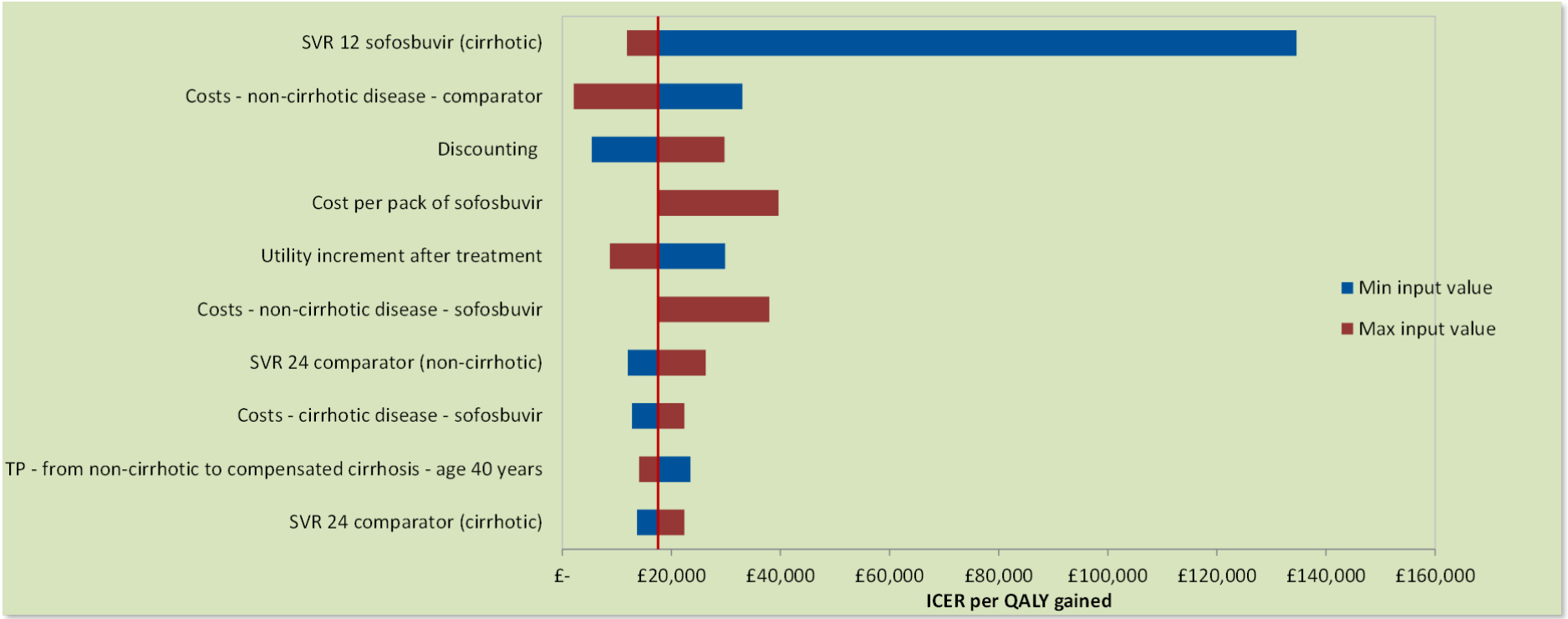
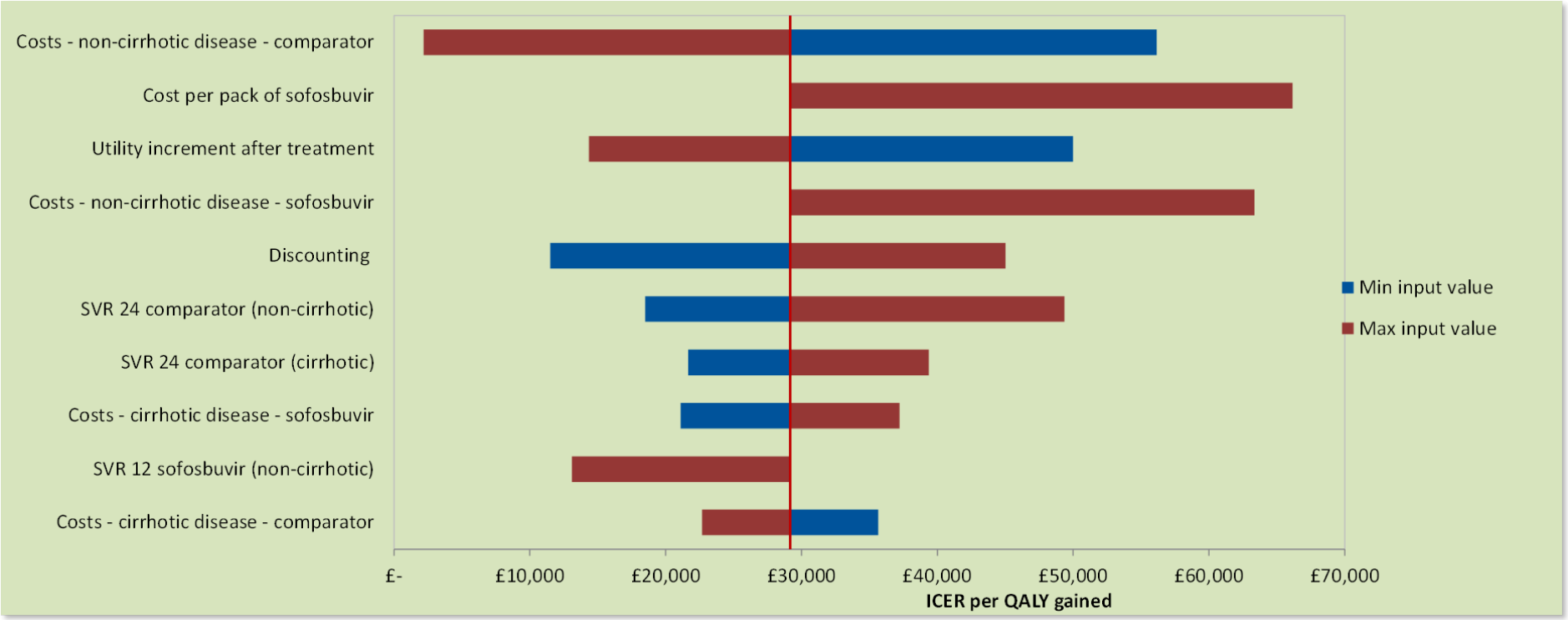

SVR 12 sofosbuvir (cirrhotic)
Costs - non-cirrhotic disease - comparator
Discounting
Cost per pack of sofosbuvir
Utility increment after treatment
Costs - non-cirrhotic disease - sofosbuvir
SVR 24 comparator (non-cirrhotic)
Costs - cirrhotic disease - sofosbuvir
TP - from non-cirrhotic to compensated cirrhosis - age 40 years
SVR 24 comparator (cirrhotic)
Min input value
Max input value
£-
£20,000
£40,000
£60,000
£80,000
£100,000
£120,000
£140,000
£160,000
ICER per QALY gained

Figure 3 Tornado diagram for SOF+PEG-IFN-2a+RBV (12 weeks) versus Telaprevir+PEG-IFN-2a+RBV in GT1 TN IFN eligible using data from the MTC

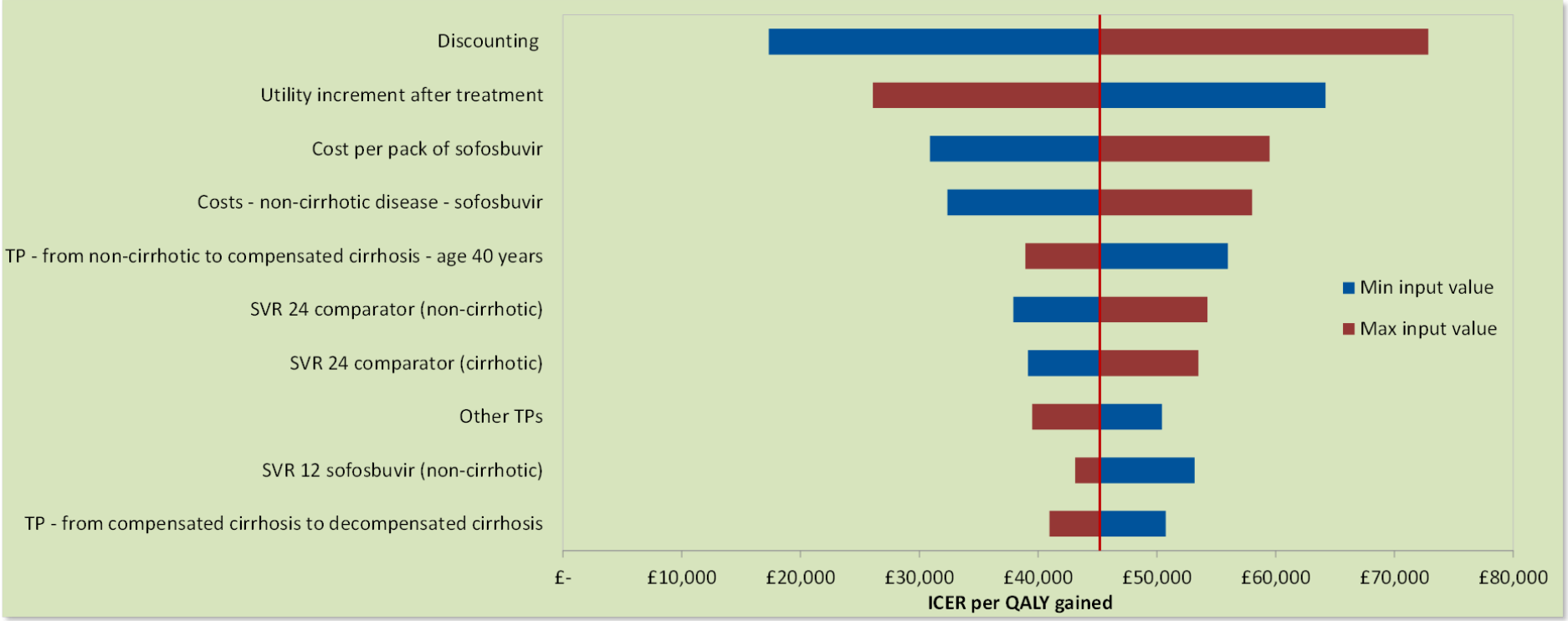


Results for genotype 2 treatment-naïve interferon eligible

Table 10 Cost-effectiveness results, GT2 TN IFN eligible using data from the MTC

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
PEG-IFN-2a+RBV (24 wks)	£13,566	21.2	15.8	NA	NA	NA	NA	NA
SOF+RBV (12 wks)	£41,224	21.7	16.4	£27,658	0.5	0.6	£45,190	£45,190

Figure 4 Tornado diagram for SOF+RBV (12 weeks) versus PEG-IFN-2a+RBV (24 weeks) in GT2 TN IFN eligible using data from the MTC



Results for genotype 3 treatment-naïve interferon eligible

Note: The meta-analysis on GT3 treatment-naïve interferon eligible patients could only be performed on the interferon-free regimen for sofosbuvir. Data for SOF + PEG-IFN-2a + RBV for 12 weeks were only available from ELECTRON, PROTON and LONESTAR-2. PROTON and LONESTAR-2 are single-arm trials in GT3 and therefore could not be connected the network. As for ELECTRON the number of patients was too low, i.e., six GT3 treatment-naïve patients received SOF + RBV and seven SOF + PEG-IFN-2a + RBV.

Table 11 Cost-effectiveness results, GT3 TN IFN eligible using data from the MTC

Technologies	Total costs (£)	Total LYG	Total QALYs	Incremental costs (£)	Incremental LYGs	Incremental QALYs	ICER vs. baseline (QALYs)	ICER incremental (QALYs)
PEG-IFN-2a+RBV (24 wks)	£18,863	20.5	14.8	NA	NA	NA	NA	NA
SOF+RBV (24 wks)	£86,542	20.5	14.8	£67,679	0.03	-0.005	Dominated	Dominated

Results of the DSA show that SOF + RBV is either dominated or originates extremely high ICERs compared with PEG-IFN-2a + RBV.