

1

TITLE PAGE



VERTEX PHARMACEUTICALS INCORPORATED

Clinical Study Protocol

**A Phase 3, Randomized, Double-Blind,
Placebo-Controlled, Crossover Study to Evaluate the
Efficacy and Safety of Ivacaftor and VX-661 in
Combination With Ivacaftor in Subjects Aged
12 Years and Older With Cystic Fibrosis,
Heterozygous for the *F508del-CFTR* Mutation, and a
Second Allele With a *CFTR* Mutation Predicted to
Have Residual Function**

Vertex Study Number: VX14-661-108



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2 PROTOCOL SYNOPSIS

Title A Phase 3, Randomized, Double-Blind, Placebo-Controlled, Crossover Study to Evaluate the Efficacy and Safety of Ivacaftor and VX-661 in Combination With Ivacaftor in Subjects Aged 12 Years and Older With Cystic Fibrosis, Heterozygous for the *F508del-CFTR* Mutation, and a Second Allele With a *CFTR* Mutation Predicted to Have Residual Function

Clinical Phase and Clinical Study Type 3, efficacy and safety

Objectives

Primary

To evaluate the efficacy of VX-661 in combination with ivacaftor and ivacaftor monotherapy through 8 weeks of treatment in subjects with cystic fibrosis (CF) who are heterozygous for the *F508del* mutation on the *CF transmembrane conductance regulator (CFTR)* gene and a second allele with a *CFTR* mutation predicted to have residual function.

Secondary

- To evaluate the safety of VX-661 in combination with ivacaftor through 8 weeks of treatment
- To evaluate the safety of ivacaftor monotherapy through 8 weeks of treatment
- To investigate the pharmacokinetics (PK) of VX-661 and its metabolite M1 (M1-661), and ivacaftor and its metabolite M1 (M1-ivacaftor)

Endpoints

Primary

- Absolute change in percent predicted forced expiratory volume in 1 second (FEV₁) from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period.

Key Secondary

- Absolute change in Cystic Fibrosis Questionnaire-Revised (CFQ-R) respiratory domain score from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period

Secondary

- Safety and tolerability assessments based on adverse events (AEs), clinical laboratory values (hematology, serum chemistry, lipid panel, vitamin levels, coagulation studies, and urinalysis), standard digital electrocardiograms (ECGs), vital signs, pulse oximetry, and spirometry
- Relative change in percent predicted FEV₁ from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period
- Absolute change in sweat chloride from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period
- PK parameters of VX-661, M1-661, ivacaftor, and M1-ivacaftor

[REDACTED]

█ [REDACTED]

█ [REDACTED]

█ [REDACTED]

█ [REDACTED]

Number of Subjects Approximately 204 subjects will be randomized (approximately 34 per sequence; sequences are described below).

Study Population Male and female subjects aged 12 years or older with CF, heterozygous for the *F508del-CFTR* mutation, and a second allele with a *CFTR* mutation predicted to have residual function.

Investigational Drug **Active substance:** VX-661 and ivacaftor
Activity: CFTR corrector and potentiator (increased chloride ion [Cl⁻] secretion)
Strength and Route of Administration: VX-661 100 mg/ivacaftor 150 mg fixed-dose combination (light yellow) film-coated tablet for oral administration

Active substance: ivacaftor
Activity: CF transmembrane potentiator (increased Cl⁻ secretion)
Strength and Route of Administration: ivacaftor 150 mg (light blue) film-coated tablet for oral administration

Active substance: not applicable
Activity: placebo
Strength and Route of Administration: 0-mg film-coated matching placebo tablets for oral administration

Study Duration Excluding the Screening Period (up to 28 days in duration), subjects will participate in this study for up to 29 weeks.
 During each of the 2 Treatment Periods, study drug (VX-661/ivacaftor, ivacaftor, or placebo) will be administered for up to 8 weeks.
 A Safety Follow-up Visit will occur 28 days ± 7 days after the final dose of study drug.

Study Design This is a Phase 3, randomized, double-blind, placebo-controlled, 2-period, 3-treatment, crossover, multicenter study in subjects aged 12 years and older with CF, heterozygous for the *F508del-CFTR* mutation, and a second allele with a *CFTR* mutation predicted to have residual function.

This study includes the following:

- Screening Period (Day -28 through Day -1)
- Treatment Period 1 (Week 1 through Week 8)
- Washout Period (a minimum of 8 weeks, from the day after the Week 8 Visit through the day before the Week 17 Visit; a Safety Evaluation Visit will be



conducted at Week 12 ± 5 days)

- Treatment Period 2 (Week 17 through Week 24)
- Safety Follow-up Visit (28 days ± 7 days after the last dose of study drug)

Subjects will be stratified by age at the Screening Visit (<18 versus ≥18 years of age), FEV₁ severity determined during the Screening Visit (<70% versus ≥70% predicted), and type of residual function mutation on the second *CFTR* allele (Class V non-canonical splice mutation versus Classes II to IV residual function mutation), and then randomized (1:1:1:1:1:1) to 1 of the following 6 treatment sequences:

- Sequence 1: VX-661/ivacaftor in Treatment Period 1 → washout → ivacaftor monotherapy in Treatment Period 2
- Sequence 2: ivacaftor monotherapy in Treatment Period 1 → washout → VX-661/ivacaftor in Treatment Period 2
- Sequence 3: VX-661/ivacaftor in Treatment Period 1 → washout → placebo in Treatment Period 2
- Sequence 4: placebo in Treatment Period 1 → washout → VX-661/ivacaftor in Treatment Period 2
- Sequence 5: ivacaftor monotherapy in Treatment Period 1 → washout → placebo in Treatment Period 2
- Sequence 6: placebo in Treatment Period 1 → washout → ivacaftor monotherapy in Treatment Period 2

A minimum of 25% of enrolled subjects will carry a Class II to IV mutation on the second *CFTR* allele. Stratification of enrollment will be managed through the interactive web response system (IWRS). Enrollment into the non-canonical splice strata will be limited to no more than 75% of total enrollment.

Schedule of Study Visits

Screening Period:

After obtaining consent and assent (where applicable), screening evaluations will be completed at any time during a period of 28 days (Day -28 through Day -1) before the first dose of the study drug.

Treatment Period:

The first dose of the study drug will be administered after randomization on Day 1.

Clinic visits will occur on Week 1 (Day 1 of Treatment Period 1), Week 2 (± 3 days), Week 4 (± 5 days), Week 8 (± 5 days), Week 12 (± 5 days), Week 17 (Day 1 of Treatment Period 2), Week 18 (± 3 days), Weeks 20 and 24 (± 5 days), and the Safety Follow-up Visit (28 days ± 7 days after the final dose of study drug).

Subjects who prematurely discontinue study drug treatment will continue to complete all the other scheduled study visits for assessments of efficacy (spirometry, sweat chloride, and CFQ-R) and [REDACTED]

through the end of the Treatment Period in which discontinuation occurred.

Safety Follow-up Visit:

The Safety Follow-up Visit is scheduled to occur 28 days (± 7 days) after the final dose of study drug. The Safety Follow-up Visit is not required for subjects who complete the Week 24 Visit and have enrolled in an extension study of VX-661 in combination with ivacaftor within 28 days after the last dose of study drug.

Assessments **Efficacy:** spirometry, sweat chloride testing, and CFQ-R.

[REDACTED]

Safety: AEs, clinical laboratory assessments (hematology, serum chemistry, lipid panel, vitamin levels, coagulation studies, and urinalysis), vital signs, physical examinations (PEs), pulse oximetry, ECGs, and spirometry.

PK: VX-661, M1-661, ivacaftor, and M1-ivacaftor.

[REDACTED]

Statistical Analyses Statistical analysis details will be provided in the Statistical Analysis Plan (SAP), which will be finalized before the clinical data lock for the study.

The null hypotheses to be tested are that the mean change from study baseline in percent predicted FEV₁ to the average of the Week 4 and Week 8 measurements is the same for (1) VX-661/ivacaftor and placebo and (2) ivacaftor monotherapy and placebo.

Assuming a standard deviation of 7 percentage points, 30 subjects per sequence are needed to have at least 90% power to detect a 3 percentage point treatment difference between VX-661/ivacaftor and placebo when the mean values of the primary endpoint are being compared. A 2-sided significance level of 0.05 was used in the sample size calculations. Accounting for the hierarchical testing strategy, the proposed sample size will yield approximately an 85% chance of observing a statistically significant difference between ivacaftor monotherapy and placebo for the primary endpoint, under the assumption that ivacaftor monotherapy is also 3 percentage points better than placebo. The sample size estimate was based on 10,000 simulation runs with an incomplete block design assuming no dropouts. After adjusting for an assumed dropout rate of 10%, the sample size was increased to 34 subjects per sequence (total of 204 subjects). The primary analysis for the primary efficacy endpoint is based on a mixed effects model. This model will include the absolute change from study baseline in percent predicted FEV₁ to the average of the Week 4 and Week 8 measurements as the dependent variable, treatment and period as fixed effects, and subject as a random effect. The within-subject covariance will be assumed to have the same compound symmetry (CS) structure for sequences containing placebo treatment which will be different from the CS structure for sequences containing active treatment in both periods.

The estimated mean treatment effect, a 95% confidence interval, and a 2-sided *P* value will be provided.

IDMC Safety Reviews The independent data monitoring committee (IDMC) will conduct regular planned safety reviews of study data as outlined in the IDMC Charter.

3 SCHEDULE OF ASSESSMENTS

Table 3-1 and Table 3-2 provide the schedule of assessments during the study, from the Screening Period through the Safety Follow-up Visit.

The Screening Period is scheduled relative to the Day 1 Visit (first dose of study drug in Table 3-2).

Table 3-1 Screening Period Assessments – Study VX14-661-108

Event/Assessment	Screening Period (Day -28 Through Day -1)
ICF and assent (when applicable)	X
Demographics	X
Medical history	X
Ophthalmological history	X
<i>CFTR</i> genotype ^a	X
CFQ-R ^b	X
██████████	██████████
Height and weight ^c	X
Ophthalmologic examination ^d	X
Complete PE	X
FSH ^e	X
Serum pregnancy test (all females of childbearing potential) ^f	X
Standard digital ECG ^g	X
Vital signs ^h	X
Pulse oximetry ^h	X
Spirometry ⁱ	X
Sweat chloride ^j	X
Urinalysis	X
Hematology	X

^a All subjects will be tested to assess *CFTR* genotype regardless of availability of a previous *CFTR* genotype laboratory report. Refer to the Laboratory Manual to determine the appropriate genotyping assay for each subject.

^b CFQ-R and ██████████ must be completed prior to the start of any other assessments scheduled at that visit.

^c Weight and height will be measured with shoes off.

^d An ophthalmologic examination will be conducted on subjects of all ages by an ophthalmologist. The ophthalmologic examination does not need to be repeated if there is documentation of an examination that met the protocol criteria and that was conducted within 3 months before the Screening Period. Subjects who have documentation of bilateral lens removal do not need an ophthalmologic exam (Section 11.7.8). Subjects with clinically significant cataracts, lens opacity, Y-suture, or lamellar rings will be excluded.

^e FSH will be measured for any potentially postmenopausal female with at least 12 months of continuous spontaneous amenorrhea. Serum FSH levels must be ≥ 40 mIU/mL to be considered postmenopausal.

^f Any female subject who does not meet the criteria for non-childbearing potential is considered to be of childbearing potential and must have a serum pregnancy test.

^g A standard digital ECG will be performed after the subject has been supine for at least 5 minutes.

^h Vital signs and pulse oximetry will be collected after the subject has been at rest (seated or supine) for 5 minutes.

ⁱ Spirometry may be performed pre- or post-bronchodilator (Section 11.6.1). Screening spirometry evaluation may be repeated, as specified in Section 8.1.1.1.

^j A sweat chloride test must be performed if an eligible sweat chloride value is not available in the subject's medical records. For subjects using a sweat chloride value documented in their medical record to establish eligibility, the sweat chloride test at the Screening Visit is optional.

Table 3-1 Screening Period Assessments – Study VX14-661-108

Event/Assessment	Screening Period (Day -28 Through Day -1)
Coagulation	X
Serum chemistry	X
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
Inclusion/exclusion criteria review	X
Prior and concomitant medications	X
AEs and SAEs	Continuous from signing of the ICF and assent (where applicable) through the Safety Follow-up Visit

AE: adverse event; CF: cystic fibrosis; CFQ-R: Cystic Fibrosis Questionnaire-Revised; CFTR: CF transmembrane conductance regulator; ECG: electrocardiogram; FSH: follicle-stimulating hormone; ICF: informed consent form; [REDACTED]; PE: physical examination; SAE: serious adverse event; [REDACTED]

^k One stool sample will be collected at the clinic or by the subject at home and provided before randomization.

In [Table 3-2](#), all visits are scheduled relative to the Day 1 Visit (first dose of study drug). The Week 2 Visit occurs after 2 weeks of treatment have been completed (i.e., Day 15 [± 3] days). The Week 8 (± 5 days) Visit occurs after 8 weeks of study drug administration have been completed (i.e., Day 57 [± 5 days]). Similarly, during Treatment Period 2, the Day 113, Week 17 Visit is the first dose of study drug for Treatment Period 2. The Week 18 Visit of Treatment Period 2 occurs after 2 weeks of treatment have been completed in Treatment Period 2 (i.e., Day 127 [± 3 days] of the study). The Week 24 (± 5 days) Visit occurs after 8 weeks of study drug administration have been completed in Treatment Period 2 (i.e., Day 169 [± 5 days]).



Table 3-2 Treatment Periods, Washout Period, ETT, and Safety Follow-up Visit Assessments – Study VX14-661-108

Event/Assessment ^b	Treatment Period 1				Washout ^a	Treatment Period 2				ETT Visit ^c	Safety Follow-up Visit 28 days (± 7 days) After Last Dose ^d
	Week 1 (Day 1)	Week 2 (Day 15) (± 3 Days)	Week 4 (Day 29) (± 5 Days)	Week 8 (Day 57) (± 5 Days)	Safety Evaluation Visit Week 12 (Day 85) (± 5 Days)	Week 17 ^a (Day 113)	Week 18 (Day 127) (± 3 Days)	Week 20 (Day 141) (± 5 Days)	Week 24 (Day 169) (± 5 Days)		
Clinic visit	X	X	X	X	X	X	X	X	X	X	X
Inclusion and exclusion criteria review	X					X ^e					
CFQ-R ^f	X		X	X	X	X		X	X	X	X
█	█		█	█	█	█		█	█	█	█
Height and weight ^g	X	X	X	X	X	X	X	X	X	X	X

^a The Washout Period starts the day after completion of the Week 8 Visit and continues for 8 weeks (+7 days). The Washout Period is considered to be complete when dosing has occurred at the Week 17 Visit.

^b All assessments will be performed before dosing unless noted otherwise. If study drug is not administered on the day of the visit (i.e., study drug interruption or premature discontinuation of study drug treatment), only 1 set of assessments will be collected. Subjects who prematurely discontinue study drug treatment will continue to complete all other scheduled study visits for assessments of efficacy (spirometry, sweat chloride, and CFQ-R) and █ through the end of the Treatment Period in which discontinuation occurred, as described in Section 8.1.6.

^c If the subject prematurely discontinues study drug treatment, an ETT Visit should be scheduled as soon as possible after the decision to terminate study treatment. Subjects who prematurely discontinue study drug treatment will also be required to complete the Safety Follow-up Visit, approximately 28 (± 7) days after their last dose of study drug. If the ETT Visit occurs 3 weeks or later following the last dose of study drug, then the ETT Visit will replace the Safety Follow-up Visit, and a separate Safety Follow-up Visit will not be required. See Section 8.1.5 and 8.1.6.

^d The Safety Follow-up Visit is not required for subjects who complete the Week 24 Visit and have enrolled in an extension study of VX-661 in combination with ivacaftor within 28 days after the last dose of study drug.

^e In order to continue in Treatment Period 2, subjects must not have an acute upper or lower respiratory infection, pulmonary exacerbation, or changes in therapy (including antibiotics) for pulmonary disease within 4 weeks before the Week 17 Visit (first dose of study drug in Treatment Period 2) and must not have any “non-CF-related” illness within 2 weeks before the Week 17 Visit. “Illness” is defined as an acute (serious or nonserious) condition (e.g., gastroenteritis). If the subjects do not meet these criteria, then the continuation of the subjects into Treatment Period 2 must be discussed with the Medical Monitor.

^f All questionnaires must be completed before the start of any other assessment scheduled for that visit. The CFQ-R must be completed first, followed by the █. Subjects will need to complete a CFQ-R and █ at the ETT Visit (Section 8.1.6).

^g Weight and height will be measured before dosing with shoes off. Height will be collected only for subjects 21 years of age or younger.



Table 3-2 Treatment Periods, Washout Period, ETT, and Safety Follow-up Visit Assessments – Study VX14-661-108

Event/Assessment ^b	Treatment Period 1				Washout ^a	Treatment Period 2				ETT Visit ^c	Safety Follow-up Visit 28 days (± 7 days) After Last Dose ^d
	Week 1 (Day 1)	Week 2 (Day 15) (± 3 Days)	Week 4 (Day 29) (± 5 Days)	Week 8 (Day 57) (± 5 Days)	Safety Evaluation Visit Week 12 (Day 85) (± 5 Days)	Week 17 ^a (Day 113)	Week 18 (Day 127) (± 3 Days)	Week 20 (Day 141) (± 5 Days)	Week 24 (Day 169) (± 5 Days)		
Ophthalmologic examination ^h										X	X
Complete PE ⁱ	X					X					
Pregnancy test ^j	urine	urine	urine	serum	urine	urine	urine	urine	serum	serum	serum
Standard digital ECG ^k	X	X	X	X	X	X	X	X	X	X	X
Vital signs ^l	X	X	X	X	X	X	X	X	X	X	X
Pulse oximetry ^l	X	X	X	X	X	X	X	X	X	X	X
Spirometry ^m	X	X	X	X	X	X	X	X	X	X	X
Sweat chloride ⁿ	X		X	X		X		X	X		
Urinalysis	X			X	X	X			X	X	X

^h Subjects < 18 years of age at screening who discontinue study drug treatment after receiving at least 1 dose of study drug, and subjects < 18 years of age at screening who complete treatment but do not enroll in a separate extension study of VX-661/ivacaftor within 28 days after the last dose of study drug will have an ophthalmologic exam conducted by a licensed ophthalmologist (see [Section 11.7.8](#)). The exam may be completed at either the ETT or Safety Follow-up Visit, but must be completed by the date of the Safety Follow-up Visit. Subjects who have documented bilateral lens removal do not need an ophthalmologic exam.

ⁱ In addition to the complete PEs indicated, symptom-targeted PEs will occur at any time during the study if triggered by AEs or if deemed necessary by the investigator.

^j Pregnancy tests will be performed for all female subjects of childbearing potential.

^k All standard digital ECGs will be performed before dosing and after the subject has been supine for at least 5 minutes. At the Week 1, Week 2, Week 17, and Week 18 Visits, ECGs will be collected before dosing and at 1.5, 3, 4, and 6 hours after the morning dose. At the Week 1, Week 2, Week 17, and Week 18 visits the 4-hour postdose ECG will be collected before the 4-hour postdose spirometry assessment. The predose ECGs collected at the Week 1 (Day 1) visit will be performed in triplicate. If study drug is not administered on the day of the visit (i.e., because of study drug interruption or permanent discontinuation of study drug), only 1 ECG will be collected.

^l Vital signs and pulse oximetry will be collected before dosing and after the subject has been at rest (seated or supine) for at least 5 minutes.

^m At all visits, spirometry must be performed for all subjects before dosing and should be performed prebronchodilator ([Section 11.6.1](#)). At Week 1, Week 2, Week 17, and Week 18, subjects < 18 years of age at the Screening Visit will have additional spirometry performed at 2 and 4 hours after the morning dose. If more than 1 spirometry assessment is required at a visit, bronchodilators will be withheld until completion of the last scheduled spirometry assessment is completed.

ⁿ The Sweat collection on dosing visits should occur approximately 1 hour before the PK sample collection and before the morning dose of the study drugs. Sweat collection will not overlap with any other study assessments ([Section 11.6.2](#)).

Table 3-2 Treatment Periods, Washout Period, ETT, and Safety Follow-up Visit Assessments – Study VX14-661-108

Event/Assessment ^b	Treatment Period 1				Washout ^a	Treatment Period 2				ETT Visit ^c	Safety Follow-up Visit 28 days (± 7 days) After Last Dose ^d
	Week 1 (Day 1)	Week 2 (Day 15) (± 3 Days)	Week 4 (Day 29) (± 5 Days)	Week 8 (Day 57) (± 5 Days)	Safety Evaluation Visit Week 12 (Day 85) (± 5 Days)	Week 17 ^a (Day 113)	Week 18 (Day 127) (± 3 Days)	Week 20 (Day 141) (± 5 Days)	Week 24 (Day 169) (± 5 Days)		
Hematology ^o	X	X	X	X	X	X	X	X	X	X	X
Coagulation ^o	X			X	X	X			X	X	X
Serum chemistry ^o	X	X	X	X	X	X	X	X	X	X	X
Lipid panel ^p	X			X		X			X	X	
Vitamin levels (A, D, E, K, B12)	X			X		X			X	X	
[REDACTED]	[REDACTED]			[REDACTED]		[REDACTED]			[REDACTED]		
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]		[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]		
[REDACTED]	[REDACTED]		[REDACTED]	[REDACTED]		[REDACTED]		[REDACTED]	[REDACTED]		
PK sampling ^u			X	X				X	X	X	X
[REDACTED]		[REDACTED]									
[REDACTED]		[REDACTED]									
[REDACTED]	[REDACTED]			[REDACTED]		[REDACTED]			[REDACTED]		[REDACTED]

^o Blood samples will be collected before the first dose of study drug.

^p Subjects will require 4 hours of fasting before the blood sample for the lipid panel is obtained.

[REDACTED]

^t The samples may be collected at the study center during the study visit or may be collected by the subject at home and brought to the study visit.

^u PK blood samples will be collected pre-morning-dose at Week 4, Week 8, Week 20, and Week 24. If study drug is not administered at the visit (i.e., study drug interruption or permanent discontinuation of study drug), a PK blood sample will still be collected. At the ETT and the Safety Follow-up Visit (as applicable), a PK blood sample will also be collected.



Table 3-2 Treatment Periods, Washout Period, ETT, and Safety Follow-up Visit Assessments – Study VX14-661-108

Event/Assessment ^b	Treatment Period 1				Washout ^a	Treatment Period 2				ETT Visit ^c	Safety Follow-up Visit 28 days (± 7 days) After Last Dose ^d
	Week 1 (Day 1)	Week 2 (Day 15) (± 3 Days)	Week 4 (Day 29) (± 5 Days)	Week 8 (Day 57) (± 5 Days)	Safety Evaluation Visit Week 12 (Day 85) (± 5 Days)	Week 17 ^a (Day 113)	Week 18 (Day 127) (± 3 Days)	Week 20 (Day 141) (± 5 Days)	Week 24 (Day 169) (± 5 Days)		
	■	■	■	■	■	■	■	■	■	■	■
Randomization ^w	X										
Meal(s) or snack(s) at site ^x	X	X	X			X	X	X			
Study drug dosing ^y	X	X	X			X	X	X			
Study drug count		X	X	X			X	X	X	X	
Concomitant medications ^z	X	X	X	X	X	X	X	X	X	X	X
Concomitant treatments and procedures	X	X	X	X	X	X	X	X	X	X	X
AEs and SAEs	Continuous from signing of the ICF and assent (where applicable) through the Safety Follow-up Visit										

AE: adverse event; β-hCG: beta-human chorionic gonadotropin; CF: cystic fibrosis; CFQ-R: Cystic Fibrosis Questionnaire–Revised; DNA: deoxyribonucleic acid; ECG: electrocardiogram; ETT: Early Treatment Termination; Eval: evaluation; ICF: informed consent form; [redacted]; IWRS: interactive web response system; [redacted]; PE: physical examination; PK: pharmacokinetic; SAE: serious adverse event; [redacted].

■ [redacted]

^w Randomization must occur after all inclusion and exclusion criteria are met and before the first dose of study drug. Randomization will be done through IWRS.

Randomization may occur on Day -1.

^x Fat-containing food, such as a “standard CF” high-fat, high-calorie meal or snack, will be provided at the site to subjects after all predose assessments have occurred.

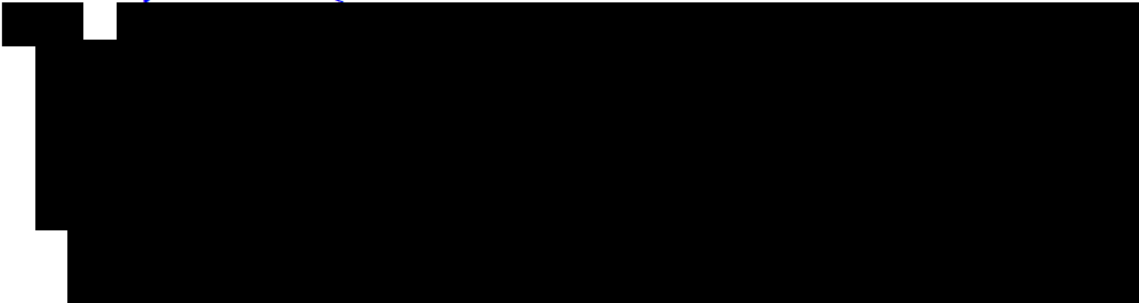
^y The study drug should be administered every 12 hours (± 2 hours) within 30 minutes after starting a meal with fat-containing food such as a “standard CF” high-fat, high-calorie meal or snack. On days of scheduled visits, the morning dose of study drug will be administered at the site after predose assessments have been completed. The final dose of study drug in Treatment Period 1 will be administered the evening before the Week 8 Visit. The final dose of study drug in Treatment Period 2 will be administered the evening before the Week 24 Visit.

^z All concomitant medications are collected through the Safety Follow-up Visit for all subjects. For subjects who prematurely discontinue study drug treatment and are followed for certain efficacy assessments after the ETT Visit (see Section 8.1.6), concomitant antibiotic therapy for ‘sinopulmonary signs/symptoms’ are collected through the Week 24 Visit, as described in Section 11.6.4.5.1.



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Glossary of Terms

Abbreviation	Definition
AE	adverse event
ALP	alkaline phosphatase
ALT	alanine aminotransferase
AM	morning
AST	aspartate aminotransferase
ATS	American Thoracic Society
β-hCG	beta-human chorionic gonadotropin
BMI	body mass index
bpm	beats per minute
CF	cystic fibrosis
CFFT TDN	Cystic Fibrosis Foundation Therapeutics Development Network
CFQ-R	Cystic Fibrosis Questionnaire–Revised
CFTR	cystic fibrosis transmembrane conductance regulator protein
<i>CFTR</i>	cystic fibrosis transmembrane conductance regulator gene
Cl ⁻	chloride ion
CPAP	Clinical Pharmacology Analysis Plan
CRO	contract research organization
CTCAE	Common Terminology Criteria for Adverse Events
CYP	cytochrome P450
DNA	deoxyribonucleic acid
EC	ethics committee
ECFS	European Cystic Fibrosis Society
ECG	electrocardiogram
eCRF	electronic case report form
EDC	electronic data capture
EENT	eyes/ears/nose/throat
EU	European Union
ERS	European Respiratory Society
ETT	Early Treatment Termination
<i>F508del</i>	<i>cystic fibrosis transmembrane conductance regulator</i> gene mutation with an in-frame deletion of a phenylalanine codon corresponding to position 508 of the wild-type protein
F508del	cystic fibrosis transmembrane conductance regulator protein lacking the phenylalanine normally found at position 508 of the wild-type protein
FAS	Full Analysis Set
FDA	Food and Drug Administration
FEF _{25%-75%}	forced expiratory flow 25% to 75%
FEV ₁	forced expiratory volume in 1 second
FSH	follicle-stimulating hormone
FVC	forced vital capacity
<i>G551D</i>	<i>cystic fibrosis transmembrane conductance regulator</i> missense gene mutation that results in the replacement of a glycine residue at position 551 of cystic fibrosis transmembrane conductance regulator with an aspartic acid residue
GCP	Good Clinical Practice

Abbreviation	Definition
GGT	gamma-glutamyl transpeptidase
GPS	Global Patient Safety
HBE	human bronchial epithelial
HR	heart rate
ICF	informed consent form
ICH	International Conference on Harmonization
IDMC	independent data monitoring committee
IEC	independent ethics committee
IRB	institutional review board
█	█
IV	intravenous
IVA	Ivacaftor (VX-770, Kalydeco)
IWRS	interactive web response system
LFT	liver function test
MedDRA	Medical Dictionary for Regulatory Activities
MMRM	mixed model repeated measures
mRNA	messenger ribonucleic acid
█	█
PBO	placebo
PCS	potentially clinically significant
PD	pharmacodynamic, pharmacodynamics
PE	physical examination
PK	pharmacokinetic, pharmacokinetics
PM	evening
q12h	every 12 hours
qd	once daily
QTc	QT interval corrected
QTcF	QT interval corrected by Fridericia's formula
SAE	serious adverse event
SAP	Statistical Analysis Plan
SD	standard deviation
█	█
SI	International System
SOP	standard operating procedure
SUSAR	suspected, unexpected, serious adverse reaction
TE	treatment emergent
TEAE	treatment-emergent adverse event
ULN	upper limit of normal
US	United States
USA	United States of America
v2	version 2
661/770	VX-661 and ivacaftor (VX-770) combination treatment
770	ivacaftor (VX-770)

5 INTRODUCTION

Cystic fibrosis (CF) affects an estimated 70,000 children and adults worldwide¹ and is the most common fatal genetic disease in persons of European descent.² Based on the size of the population, CF qualifies as an orphan disease.^{3,4} Despite progress in the treatment of CF with antibiotics and mucolytics, the predicted median age of survival for a person with CF is in the mid-30s.^{2,5} Although the disease affects multiple organs, most morbidity and mortality are caused by progressive loss of lung function.⁶

CF is an autosomal recessive genetic disease caused by a defect in the gene encoding the CF transmembrane conductance regulator (CFTR), an epithelial chloride ion (Cl⁻) channel activated by cyclic adenosine monophosphate-dependent protein kinase A that is responsible for aiding in the regulation of salt and water absorption and secretion in various tissues.² This function is defective in patients with CF due to a loss of either cell surface expression and/or function.

More than 1900 mutations in the *CFTR* gene have been identified.⁷ Mutations in the *CFTR* gene have been classified based on the molecular and functional consequence of the mutation on the CFTR protein^{8,9,10} and can be generally considered to reduce the quantity of functional CFTR protein that reaches the epithelial cell surface or reduce the function of CFTR protein located at the cell surface. *CFTR* gene mutations that affect the quantity of functional cell surface CFTR protein include defects that reduce CFTR protein synthesis and defects that impede the cellular processing and delivery of CFTR proteins to the cell surface.

CFTR gene mutations associated with minimal CFTR function include

- mutations associated with severe defects in ability of the CFTR channel to open and close, known as defective channel gating or "gating mutations";
- severe defects in the cellular processing of CFTR and its delivery to the cell surface;
- no (or minimal) CFTR synthesis; and
- severe defects in channel conductance.

The most prevalent mutation is an in-frame deletion in the *CFTR* gene resulting in a loss of phenylalanine at position 508 in the CFTR protein (F508del-CFTR).¹⁰ In the US, almost 87% of patients with CF have at least 1 copy of the *F508del-CFTR* mutation, and about 47% have 2 copies.¹¹ In the European Union (EU), approximately 83% of patients with CF have 1 or 2 copies of the *F508del-CFTR* mutation, and approximately 38.7% of patients with CF in the United Kingdom have 2 copies.¹² The *F508del-CFTR* mutation interferes with the ability of the CFTR protein to reach and remain at the cell surface, as well as to open and close, resulting in decreased Cl⁻ transport.^{13,14} The combined effect is a marked reduction in F508del-CFTR-mediated Cl⁻ secretion that impairs fluid regulation and promotes accumulation of thick, sticky mucus in the airway. The mucus build-up obstructs the airways and predisposes the patient to chronic lung infections.¹⁵

Two complementary approaches to increase CFTR-mediated Cl^- secretion in the airway epithelia have been studied.⁹ One approach is to treat with a compound that will modify the cellular processing and trafficking of the CFTR protein to increase the amount of functional CFTR at the cell surface. This kind of compound has been termed a CFTR corrector. Another approach is to treat with a compound that increases the channel gating activity of protein kinase A-activated CFTR at the cell surface to enhance ion transport. This kind of compound has been termed a potentiator. Depending on the amount of residual CFTR channel activity in the membrane and the pathophysiology of that activity (reflecting the CFTR genotype of the patient and possibly other factors), both approaches may be required to ameliorate lung disease in patients with CF. A modest restoration of Cl^- secretion through the action of a potentiator and/or corrector could prevent the hyperabsorption of water across the apical surface of epithelial cells, allowing proper maintenance of airway hydration. Adequate airway hydration could alleviate the cycle of mucus plugging, infection, and inflammation, which leads to irreversible structural changes in the lungs and, eventually, respiratory failure for patients with CF.

Residual function mutations are Class II through V mutations that have some residual chloride transport and result in a less severe clinical phenotype. Despite slower disease progression, patients with residual function mutations still develop chronic pulmonary disease, pulmonary exacerbations, and pancreatic insufficiency, and overall have a reduced lifespan. Ivacaftor (a potentiator) has been shown to increase the chloride transport in these mutations by increasing the open channel probability. Populations of patients with these mutations are both genotypically and phenotypically diverse, and it is anticipated that the second *CFTR* allele will have some responsiveness to a potentiator. Mutations were identified using 2 criteria: in vitro response to ivacaftor and population-level clinical phenotype from epidemiologic data¹⁶ or published literature.¹⁷⁻²⁴

VX-661 is a compound developed by Vertex Pharmaceuticals Incorporated (Vertex) that has been shown to have CFTR corrector properties. Several lines of in vitro evidence suggest that VX-661 works by promoting the proper cellular processing and trafficking of a fraction of F508del-CFTR protein during its biogenesis and processing in the endoplasmic reticulum, allowing it to exit the endoplasmic reticulum and traffic the cell surface.²⁵ When added for more than 24 hours to human bronchial epithelial (HBE) cells isolated and cultured from lung explants obtained from donors with CF (CF-HBE cells) who are homozygous for the *F508del-CFTR* mutation, a concentration-dependent increase in levels of mature (i.e., plasma membrane) F508del-CFTR was observed. The increased trafficking of F508del-CFTR to the cell surface resulted in a significant increase in Cl^- secretion.²⁵ VX-661 did not correct the processing and localization of other misfolded or normally folded proteins other than CFTR, suggesting that the mechanism of VX-661 action is selective for CFTR (CFTR corrector).²⁶

Ivacaftor (also known as VX-770) is the first CFTR modulator to show an improvement in CFTR function and clinical benefit in patients with CF. Results from several Phase 3 studies showed that ivacaftor is effective in the treatment of patients with CF who have mutations that result in gating defects, as evidenced by sustained improvements in CFTR channel function (measured by reduction in sweat chloride concentration) and corresponding substantial, durable improvements in lung function, respiratory symptoms, and weight gain.



Ivacaftor was also well tolerated, as evidenced by the rates and reasons for premature discontinuation and results of safety assessments.

As of July 2015, in the US, Kalydeco is indicated for the treatment of CF in patients age 2 years and older who have one of the following mutations in the *CFTR* gene: *G551D*, *G1244E*, *G1349D*, *G178R*, *G551S*, *S1251N*, *S1255P*, *S549N*, *S549R*, or *R117H*. In the EU and in Israel, Kalydeco is indicated for the treatment of CF in patients age 6 years and older who have one of the following mutations in the *CFTR* gene: *G551D*, *G1244E*, *G1349D*, *G178R*, *G551S*, *S1251N*, *S1255P*, *S549N*, or *S549R*. In Canada, Kalydeco is indicated for the treatment of CF in patients age 6 years and older who have one of the following mutations in the *CFTR* gene: *G551D*, *G1244E*, *G1349D*, *G178R*, *G551S*, *S1251N*, *S1255P*, *S549N*, *S549R*, or *G970R*. It is also indicated for the treatment of CF in patients age 18 years and older who have the *R117H* mutation in the *CFTR* gene. In Australia, Kalydeco is indicated for the treatment of CF in patients age 6 years and older who have a *G551D* or other gating (class III) mutation in the *CFTR* gene. In New Zealand, Switzerland, and Liechtenstein, Kalydeco is currently indicated for the treatment of CF in patients 6 years of age and older who have the *G551D* mutation.

Details about the VX-661 and ivacaftor development programs can be found in the Investigator's Brochures.^{27,28}

6 STUDY OBJECTIVES

6.1 Primary Objectives

To evaluate the efficacy of VX-661 in combination with ivacaftor and ivacaftor monotherapy through 8 weeks of treatment in subjects with CF who are heterozygous for the *F508del* mutation on the *CFTR* gene and a second allele with a *CFTR* mutation predicted to have residual function.

6.2 Secondary Objectives

- To evaluate the safety of VX-661 in combination with ivacaftor through 8 weeks of treatment
- To evaluate the safety of ivacaftor monotherapy through 8 weeks of treatment
- To investigate the pharmacokinetics (PK) of VX-661 and its metabolite M1 (M1-661), and ivacaftor and its metabolite M1 (M1-ivacaftor)

7 STUDY ENDPOINTS

7.1 Primary Endpoint

Absolute change in percent predicted forced expiratory volume in 1 second (FEV₁) from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period.

7.2 Key Secondary Endpoint

- Absolute change in Cystic Fibrosis Questionnaire-Revised (CFQ-R) respiratory domain score from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period

7.3 Secondary Endpoints

- Safety and tolerability assessments based on adverse events (AEs), clinical laboratory values (hematology, serum chemistry, lipid panel, vitamin levels, coagulation studies, and urinalysis), standard digital electrocardiograms (ECGs), vital signs, pulse oximetry, and spirometry
- Relative change in percent predicted FEV₁ from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period
- Absolute change in sweat chloride from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period
- PK parameters of VX-661, M1-661, ivacaftor, and M1-ivacaftor

7.4

- █ [REDACTED]
- █ [REDACTED]
- █ [REDACTED]
- █ [REDACTED]
- █ [REDACTED]
- █ [REDACTED]
- █ [REDACTED]

8 STUDY DESIGN

8.1 Overview of Study Design

This is a Phase 3, randomized, double-blind, placebo-controlled, 2-period, 3-treatment, crossover, multicenter study in subjects aged 12 years and older with CF, heterozygous for the *F508del-CFTR* mutation, and a second allele with a *CFTR* mutation predicted to have residual function. A summary of mutations predicted to have residual function is in [Section 16](#). This study is designed to evaluate (i) the efficacy and safety of VX-661 in combination with ivacaftor (VX-661/ivacaftor) and (ii) the efficacy and safety of ivacaftor monotherapy in this patient population using an incomplete block design.

The treatment regimens will be



- VX-661/ivacaftor combination treatment
 - o Morning dose: 1 tablet fixed-dose combination of VX-661 100 mg/ivacaftor 150 mg and 1 tablet ivacaftor placebo
 - o Evening dose: 1 tablet ivacaftor 150 mg
- Ivacaftor monotherapy
 - o Morning dose: 1 tablet placebo visually matched to the fixed-dose combination tablet and 1 tablet ivacaftor 150 mg
 - o Evening dose: 1 tablet ivacaftor 150 mg
- Placebo
 - o Morning dose: 1 tablet placebo visually matched to the fixed-dose combination tablet and 1 tablet placebo visually matched to ivacaftor 150 mg
 - o Evening dose: 1 tablet placebo visually matched to ivacaftor 150 mg

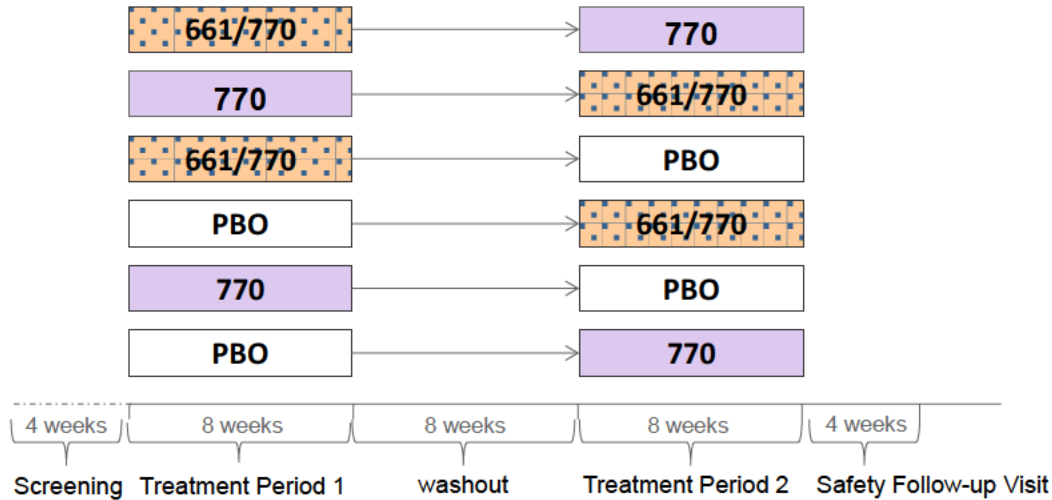
This study includes a Screening Period (approximately 28 days), Treatment Period 1 (8 weeks), Washout Period (8 weeks), Treatment Period 2 (8 weeks), and Safety Follow-up Visit (approximately 28 days). Approximately 204 subjects (34 per sequence) will be enrolled and stratified by age at the Screening Visit (<18 versus \geq 18 years of age), FEV₁ severity (determined during the Screening Visit; <70% versus \geq 70% predicted), and type of residual function mutation on the second *CFTR* allele (Class V non-canonical splice mutation versus Classes II to IV residual function mutation; see [Section 16](#)), and then randomized (1:1:1:1:1:1) to 1 of the 6 treatment sequences, as shown in [Figure 8-1](#). A minimum of 25% of enrolled subjects will carry a Class II to IV mutation on the second *CFTR* allele (see [Section 16](#)). Stratification of enrollment will be managed through the interactive web response system (IWRS). Enrollment into the non-canonical splice strata will be limited to no more than 75% of total enrollment.

- Sequence 1: VX-661/ivacaftor in Treatment Period 1→washout→ivacaftor monotherapy in Treatment Period 2
- Sequence 2: ivacaftor monotherapy in Treatment Period 1→washout→VX-661/ivacaftor in Treatment Period 2
- Sequence 3: VX-661/ivacaftor in Treatment Period 1→washout→placebo in Treatment Period 2
- Sequence 4: placebo in Treatment Period 1→washout→VX-661/ivacaftor in Treatment Period 2
- Sequence 5: ivacaftor monotherapy in Treatment Period 1→washout→ placebo in Treatment Period 2
- Sequence 6: placebo in Treatment Period 1→washout→ivacaftor monotherapy in Treatment Period 2

Subjects who complete the Week 24 Visit will be offered the opportunity to enroll in an extension study, if they meet the eligibility criteria for the extension study.

Subjects who prematurely discontinue study drug treatment will continue to complete all other scheduled study visits through the end of the Treatment Period in which discontinuation occurred, as detailed in [Section 8.1.6](#).

Figure 8-1 Schematic of the Study Design



661/770: VX-661 and ivacaftor (VX-770) combination treatment; 770: ivacaftor (VX-770); PBO: placebo.

8.1.1 Screening

The Screening Period will occur within 28 days before the first dose of study drug to determine whether subjects meet the selection criteria for the study. The assessments to be conducted are shown in [Table 3-1](#). The investigator (or an appropriate authorized designee) will obtain informed consent and assent, if applicable, from each subject.

The ophthalmologic examination does not need to be repeated if there is documentation of an examination that met protocol criteria and that was conducted within 3 months before the Screening Period, or if the subject has documentation of bilateral lens removal ([Section 11.7.8](#)).

8.1.1.1 Repetition of Screening Assessment(s)

Repetition of individual screening assessment(s) that did not meet eligibility criteria is not permitted with the following exceptions:

- If there is clear evidence of a laboratory error (e.g., hemolyzed sample) or equipment malfunction, collection of a repeat sample for the appropriate laboratory test or assessment may be permitted with the approval of the Medical Monitor.
- Exclusionary liver function test (LFT) levels, which may be retested within 14 days after the original screening date.
- If screening spirometry measurements fail to meet acceptability and repeatability criteria as specified by the American Thoracic Society (ATS)/European Respiratory Society (ERS) guidelines,²⁹ repeat spirometry evaluation may be performed once.



If repeat values of the individual assessment(s) are within the eligibility criteria and completed within the screening window, then the subject is eligible for the study.

8.1.1.2 Rescreening

Subjects may only be rescreened with the approval of the Medical Monitor. If a subject is rescreened, all screening assessments will be repeated except for *CFTR* genotyping, follicle-stimulating hormone (FSH) level (if serum FSH level was ≥ 40 mIU/mL during prior screening), sweat chloride, and ophthalmologic examination (if performed within the last 3 months). If a subject is rescreened, the screening window will begin once the first rescreening assessment has been initiated.

8.1.1.3 Extension of the Screening Period Window

A subject may have the Screening Period window extended by 2 weeks for the following reasons:

- Repetition of the Screening Period assessments ([Section 8.1.1.1](#))
- Unexpected operational or logistic delays, or to meet the eligibility criteria
- Additional time to conduct ophthalmologic examinations ([Section 11.7.8](#))

8.1.2 Treatment Period 1 (8 Weeks)

Treatment Period 1 will last approximately 8 weeks. Subjects will be randomized to 1 of 6 sequences, as shown in [Section 8.1](#).

For subjects who are on a stable regimen of inhaled cycling antibiotics, the Treatment Period 1 Day 1 Visit should be timed to occur at the end of an off-cycle but no less than 14 days after the last dose of inhaled antibiotics in the previous on-cycle. The first dose of study drug will be administered on Treatment Period 1 Day 1. Dosing details are given in [Section 10.2](#). The first dose of a new cycle of inhaled cycling antibiotic should also occur on Treatment Period 1 Day 1.

Study visits during the Treatment Period will occur as shown in [Table 3-2](#). Subjects will be outpatients during the Treatment Period. All visits should occur within the windows specified.

Subjects who prematurely discontinue study drug treatment during Treatment Period 1 will complete assessments through the Week 8 Visit as described in [Section 8.1.6](#).

8.1.3 Washout Period (8 Weeks)

The Washout Period starts the day after completion of the Week 8 Visit. It has a duration of 8 weeks (+ 7 days) but may be extended with approval from the Medical Monitor. A safety evaluation visit will be conducted at Week 12 (± 5 days).

8.1.4 Treatment Period 2 (8 Weeks)

Treatment Period 2 will last approximately 8 weeks. In order to continue in Treatment Period 2, subjects must not have an acute upper or lower respiratory infection, pulmonary exacerbation, or changes in therapy (including antibiotics) for pulmonary disease within 4 weeks before the Week 17 Visit (first dose of study drug in Treatment Period 2) and must

not have any “non-CF-related” illness within 2 weeks before the Week 17 Visit. “Illness” is defined as an acute (serious or nonserious) condition (e.g., gastroenteritis). If the subjects do not meet these criteria, then the continuation of the subjects into Treatment Period 2 must be discussed with the Medical Monitor.

For subjects who are on a stable regimen of inhaled cycling antibiotics, the Treatment Period 2 Week 17 Visit should be timed to occur at the end of an off-cycle but no less than 14 days after the last dose of inhaled antibiotics in the previous on-cycle. The first dose of study drug in Treatment Period 2 will be administered at the Week 17 Visit. Dosing details are given in [Section 10.2](#). The first dose of a new cycle of inhaled cycling antibiotic should also occur on the Treatment Period 2 Week 17 Visit.

Study visits during the Treatment Period 2 will occur as shown in [Table 3-2](#). Subjects will be outpatients during the Treatment Period. All visits should occur within the windows specified.

Subjects who prematurely discontinue study drug treatment during Treatment Period 2 will remain in the study from the time of discontinuation of study drug treatment through the Week 24 Visit and complete assessments for all study visits, as described in [Section 8.1.6](#).

8.1.5 Follow-up

The Safety Follow-up Visit assessments are listed in [Table 3-2](#). There will be an outpatient Safety Follow-up Visit 28 days \pm 7 days after the last dose of study drug for subjects who complete study drug treatment and for subjects who prematurely discontinue study drug treatment.

The Safety Follow-up Visit is not required for subjects who complete the Week 24 Visit and have enrolled in an extension study of VX-661 in combination with ivacaftor within 28 days after the last dose of study drug.

8.1.6 Early Treatment Termination

If the subject prematurely discontinues study drug treatment or is withdrawn from the study, an Early Treatment Termination (ETT) Visit should be scheduled as soon as possible after the last dose of study drug. Such subjects will also be required to complete the Safety Follow-up Visit, approximately 28 days \pm 7 days after their last dose of study drug. The assessments performed at the Safety Follow-up Visit are listed in [Table 3-2](#).

If the ETT Visit occurs 3 weeks or later following the last dose of study drug, then the ETT Visit will replace the Safety Follow-up Visit, and a separate Safety Follow-up Visit will not be required.

Subjects who prematurely discontinue study drug treatment will continue to complete all other scheduled study visits for assessments of efficacy (spirometry, sweat chloride, and CFQ-R) and [REDACTED]

[REDACTED] through the end of the Treatment Period in which discontinuation occurred, as detailed in the Schedule of Assessments ([Section 3](#)).

If the subject withdraws from the study and also withdraws consent for disclosure of future information, no further evaluations will be performed, and no additional data will be

collected. Vertex may retain and continue to use any data collected before such withdrawal of consent.

8.1.7 Independent Data Monitoring Committee

The safety of administration of VX-661 in combination with ivacaftor will be monitored by an external independent data monitoring committee (IDMC), which will conduct periodic reviews of safety data. Procedural details of the IDMC structure and function, frequency of meetings, and data planned for review will be included in the IDMC Charter. The IDMC Charter will be finalized before the first subject is screened.

8.2 Rationale for Study Design and Study Drug Regimens

8.2.1 Study Design

The present study is 1 of 4 pivotal, Phase 3 clinical studies designed to demonstrate the clinical efficacy and safety of ivacaftor and VX-661 in combination with ivacaftor in subjects with CF. A randomized, double-blind study design will prevent observer bias and reduce symptoms or outcomes arising from the subjects' knowledge of treatment. The study evaluates the efficacy and safety of 1 dose level of VX-661 (100 mg once daily [qd]) in combination with ivacaftor (150 mg every 12 hours [q12h]) as well as the efficacy and safety of 1 dose level of ivacaftor monotherapy (150 mg q12h).

Subjects enrolled into this study will be heterozygous for the *F508del-CFTR* mutation, a processing mutation anticipated to respond to the combination of VX-661 and ivacaftor based on "proof-of-concept" Study VX-11-661-101 (Study 101). Results from Study 101, Group 7, in subjects heterozygous for *F508del-CFTR* and *G551D-CFTR*, suggest that clinically meaningful improvement in percent predicted FEV₁ can be achieved with the combination of VX-661 and ivacaftor, even in the presence of a single *F508del-CFTR* allele when the second allele is also responsive to potentiator modulation.

A crossover design with randomization to 6 treatment sequences will enable within-subject comparison of the effects of VX-661 in combination with ivacaftor and ivacaftor monotherapy. This design enhances the power to detect treatment differences by reducing the inherent between-subject variability present in a parallel-arm study. This is particularly important in studying the *F508del-CFTR*/residual function population, which has a low genotypic incidence (approximately 7% of the CF population worldwide). Furthermore, this population, as a whole, is heterogeneous with regard to baseline disease as well as potential degree of response to corrector and potentiator therapies.

There are no approved therapies for treatment of subjects with *F508del-CFTR*/residual function that target the underlying mechanism of the disease that could be used as an active comparator for VX-661 in combination with ivacaftor or ivacaftor monotherapy. Therefore, the use of placebo in this study is deemed ethical and necessary to adequately assess the benefit of treatment with VX-661 in combination with ivacaftor and treatment with ivacaftor monotherapy. All subjects enrolled in the study will continue their normal, stable treatment for CF symptoms throughout the study.

8.2.2 Study Drug Dose and Duration

The dose regimen of VX-661 chosen for continued development in Phase 3 was studied in Study 101 in 2 CF populations: *F508del-CFTR* homozygous subjects (Group 4) and *F508del-CFTR* heterozygous subjects who had *G551D-CFTR* on the other allele (Group 7). The dose regimen of VX-661 100 mg qd in combination with ivacaftor 150 mg q12h provided clinically meaningful and statistically significant improvements in percent predicted FEV₁ in both populations as well as a signal of CFTR modulation as assessed by the change in sweat chloride.

The dose regimen of ivacaftor planned for this study (150 mg q12h) is the current labeled dose regimen for patients with CF with gating mutations who are aged 6 years and older.

An 8-week period was selected as the duration for Treatment Periods 1 and 2. A significant response in FEV₁ is anticipated to be observed after 2 to 4 weeks of treatment with VX-661 in combination with ivacaftor. The primary endpoint, which is the absolute change in percent predicted FEV₁ from study baseline to the average of measurements at Weeks 4 and 8 in each Treatment Period, was selected in order to obtain a more robust assessment of the durability of response that is less affected by short-term variability in FEV₁. An 8-week period was selected as the duration for the Washout Period. Based on PK data collected in the healthy subjects (Study VX07-661-001 [Study 001]), the terminal half-life of VX-661 is approximately 116 hours.²⁷ For ivacaftor, the estimated terminal half-life is approximately 12 hours. Thus, following an 8-week washout, negligible concentration of VX-661 and ivacaftor is expected to remain in study subjects. Based on preliminary efficacy data from Study VX11-661-101 and efficacy data from previous ivacaftor studies, no residual effects of VX-661/ivacaftor combination therapy and ivacaftor monotherapy are expected by the end of the 8-week washout period.

8.2.3 Rationale for Study Population

The study population will be subjects with CF who are 12 years of age and older and are heterozygous for the *F508del-CFTR* mutation and with a second *CFTR* mutation predicted to have residual function. Based on the results from Study 101 (Section 8.2.1), subjects with the *F508del-CFTR* mutation on only 1 allele may respond to VX-661/ivacaftor treatment when the second allele is also responsive to potentiator modulation. The inclusion of subjects with CF who are 12 to 17 years of age is justified based on severity of disease and allometric scaling. The overall disease status for the adolescent and adult populations to be enrolled in this study is anticipated to be similar based on the identical enrollment criteria, particularly the FEV₁ (i.e., FEV₁ ≥40% and ≤90% of predicted normal for age, sex, and height at screening) and the requirement for clinical stability. Additionally, the expected maturity of the cytochrome P450 (CYP) enzymes in adolescents supports their inclusion. The dose regimen of ivacaftor planned for this study (150 mg q12h) is the current labeled dose regimen for patients with CF with gating mutations who are aged 6 years and older. Based on the historical data from the ivacaftor Phase 3 program and the US CF Foundation Registry on weight as a function of age in patients with CF, weights in the adolescent population are expected to be only slightly lower than those of the adult CF population.

8.2.4 Rationale for Study Assessments

The safety and PK assessments are standard parameters for clinical studies in drug development. The efficacy assessments are widely accepted and generally recognized as reliable, accurate, and relevant to the study of patients with CF.

Spirometry: Since lung disease is the major cause of morbidity and mortality for patients with CF, CF lung disease is the desired primary target of VX-661/ivacaftor combination treatment. Spirometry (as measured by FEV₁) is the most widely implemented standardized assessment to evaluate lung function. Spirometry assessments must be performed predose in all subjects according to the Schedule of Assessments (Table 3-1 and Table 3-2). To meet a request from a regulatory authority, subjects < 18 years of age at the Screening Visit will have additional spirometry assessments performed after dosing at the time points noted in Table 3-2.

Sweat Chloride Testing: In patients with CF, the underlying ion-transport defect in CFTR results in elevated sweat electrolyte levels.^{30,31} The sweat chloride test (quantitative pilocarpine iontophoresis) is the most common diagnostic tool for CF. A sweat chloride concentration of ≥60 mmol/L is considered to indicate CF, whereas <40 mmol/L is considered normal. Based on the mechanisms of action of VX-661 and ivacaftor, the sweat chloride test was included in this study as a measure of the effect of ivacaftor and VX-661 in combination with ivacaftor on CFTR activity.

CFQ-R: The CFQ-R is a frequently used CF-specific instrument that measures the health-related quality of life of patients with CF.^{32,33,34} As both ivacaftor and VX-661/ivacaftor are systemic therapies, they have the potential to improve respiratory symptoms as well as other extrapulmonary manifestations of CF. These improvements can be captured by the non-respiratory symptoms domains of the CFQ-R. Linguistically validated versions of the CFQ-R^{35,36} are available, thereby allowing consistent interpretation of the results in this global study. The CFQ-R will be used to capture and evaluate the impact of ivacaftor and VX-661/ivacaftor on patient report of respiratory symptoms and other aspects of health-related quality of life.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

9 STUDY POPULATION

Eligibility will be reviewed and documented by an appropriately qualified member of the investigator's team before subjects are enrolled.

9.1 Inclusion Criteria

Subjects who meet all of the following inclusion criteria will be eligible:

1. Subject (or their legally appointed and authorized representative) will sign and date an informed consent form (ICF) and, where appropriate, an assent form.
2. Willing and able to comply with scheduled visits, treatment plan, study restrictions, laboratory tests, contraceptive guidelines, and other study procedures.
3. Subjects (males and females) will be aged 12 years or older on the date of informed consent or, where appropriate, assent.
4. Heterozygous for *F508del-CFTR* and a second allele with a *CFTR* mutation predicted to have residual function (see [Section 16](#)). The results of the confirmatory genotype sample obtained during screening must be reviewed before randomization. *CFTR* mutations that are predicted to have residual function were defined using the parameters in [Section 16](#).
5. $FEV_1 \geq 40\%$ and $\leq 90\%$ of predicted normal for age, sex, and height (equations of Wang et al. or Hankinson et al.)^{43,44} during screening. Spirometry measurements must meet ATS/ERS criteria²⁹ for acceptability and repeatability ([Section 8.1.1.1](#)).

Subjects must meet Inclusion Criterion 6 or 7.

6. Sweat chloride value ≥ 60 mmol/L from test results obtained during screening OR as documented in the subject's medical record.
7. If the sweat chloride value is < 60 mmol/L, there must be documented evidence of chronic sinopulmonary disease⁴⁵ manifested by (but not limited to) at least 1 of the following:
 - o Persistent colonization/infection with typical CF pathogens, including *Staphylococcus aureus*, *Haemophilus influenzae*, and mucoid and nonmucoid *Pseudomonas aeruginosa*
 - o Chronic cough and sputum production
 - o Persistent chest radiograph abnormalities (e.g., bronchiectasis, atelectasis, infiltrates, hyperinflation)
 - o Nasal polyps, chronic sinusitis; radiographic or computed tomographic abnormalities of the paranasal sinuses

Specific criteria for such subjects must be discussed with and approved by the Medical Monitor prior to randomization.

8. Stable CF disease as judged by the investigator.
9. Willing to remain on a stable CF medication regimen through Week 24 or, if applicable, the Safety Follow-up Visit.

9.2 Exclusion Criteria

Subjects who meet any of the following exclusion criteria will **not** be eligible:

1. History of any comorbidity that, in the opinion of the investigator, might confound the results of the study or pose an additional risk in administering study drug to the subject. For example:
 - o history of cirrhosis with portal hypertension and/or history of risk factors for Torsades de Pointes (e.g., familial long QT syndrome, hypokalemia, heart failure, left ventricular hypertrophy, bradycardia, myocardial infarction, cardiomyopathy, history of arrhythmia [ventricular and atrial fibrillation], obesity, acute neurologic events [subarachnoid hemorrhage, intracranial hemorrhage, cerebrovascular accident, and intracranial trauma], and autonomic neuropathy)
2. Any of the following abnormal laboratory values at Screening Visit:
 - o Hemoglobin <10 g/dL
 - o Abnormal liver function defined as any 2 or more of the following: $\geq 3 \times$ upper limit of normal (ULN) aspartate aminotransferase (AST), $\geq 3 \times$ ULN alanine aminotransferase (ALT), $\geq 3 \times$ ULN gamma-glutamyl transpeptidase (GGT), $\geq 3 \times$ ULN alkaline phosphatase (ALP), or $\geq 2 \times$ ULN total bilirubin
 - o Abnormal liver function defined as any increase of $\geq 5 \times$ ULN AST or ALT
 - o Abnormal renal function defined as glomerular filtration rate ≤ 50 mL/min/1.73 m² (calculated by the Modification of Diet in Renal Disease Study Equation)^{46,47} for subjects ≥ 18 years of age and ≤ 45 mL/min/1.73 m² (calculated by the Counahan-Barratt equation)⁴⁸ for subjects aged 12 to 17 years (inclusive)
3. An acute upper or lower respiratory infection, pulmonary exacerbation, or changes in therapy (including antibiotics) for pulmonary disease within 28 days before Day 1 (first dose of study drug)
4. A 12-lead ECG demonstrating QTc >450 msec at the Screening Visit. If QTc exceeds 450 msec for the screening ECG, the ECG should be repeated 2 more times during the Screening Period, and the average of the 3 QTc values should be used to determine the subject's eligibility.
5. History of solid organ or hematological transplantation.
6. History or evidence of cataract, lens opacity, Y-suture, or lamellar rings determined to be clinically significant by the ophthalmologist during the ophthalmologic examination during the Screening Period. The ophthalmologic examination does not need to be repeated if there is documentation of an examination meeting protocol criteria that was conducted within 3 months before the Screening Period. If the subject has documentation of bilateral lens removal, an ophthalmologic examination is not required and this criterion is not applicable ([Section 11.7.8](#)).
7. History of alcohol or drug abuse, as deemed by the investigator, in the past year, including but not limited to cannabis, cocaine, and opiates.

8. Ongoing or prior participation in an investigational drug study (including studies investigating VX-661, lumacaftor [VX-809], and/or ivacaftor) or use of commercially available CFTR modulator (e.g., Kalydeco) within 30 days of screening.
 - o A washout period of 30 days or 5 terminal half-lives of the previous investigational study drug or the commercially available CFTR modulator, whichever is longer, must elapse before screening. The duration of the elapsed time may be longer if required by local regulations.
 - o Subjects who discontinue from Study VX12-809-105 after randomization will not be eligible to participate in this study.
 - o Ongoing participation in a noninterventional study (including observational studies and studies requiring assessments without administration of study drug) is permitted.
9. Use of restricted medications or foods within the specified window before the first dose of study drug as defined in [Table 9-1](#).
10. Pregnant and nursing females (females of childbearing potential must have a negative pregnancy test at Screening and Day 1).
11. Sexually active subjects of reproductive potential who are not willing to follow the contraception requirements outlined in [Section 11.7.5](#).
12. The subject or a close relative of the subject is the investigator or a subinvestigator, research assistant, pharmacist, study coordinator, or other staff directly involved with the conduct of the study. An adult (aged 18 years or older) who is a relative of a study staff member may be randomized in the study provided that
 - o the adult lives independently of and does not reside with the study staff member
 - o the adult participates in the study at a site other than the site at which the family member is employed
13. Colonization with organisms associated with a more rapid decline in pulmonary status (e.g., *Burkholderia cenocepacia*, *Burkholderia dolosa*, and *Mycobacterium abscessus*). For subjects who have had a history of a positive culture in the past, the investigator could be guided by the following suggested criteria for a subject to be considered free of colonization:
 - o The subject should have had 2 respiratory tract cultures negative for these organisms within the past 12 months, with no subsequent positive cultures
 - o These 2 respiratory tract cultures should have been separated by at least 3 months
 - o One of these 2 respiratory tract cultures should have been obtained within the past 6 months
14. Subjects will not be eligible to participate in optional NPD assessments if they have any additional medical conditions or physical or other complaints that in the opinion of the investigator may place the subject at significant risk, affect the performance of the procedure, or limit the interpretation of the test, including but not limited to:
 - o Abnormalities of the nasal passages

- o Required use of continuous (24 hours/day) supplemental oxygen by nasal cannula
- o Intranasal medication changes within 14 days prior to receiving the first dose of study drug (including corticosteroids, cromolyn, phenylephrine, etc.).

9.3 Study Restrictions

9.3.1 Additional Dietary Restrictions/Prohibited Medications

Prohibited medications and certain foods are not allowed in this study (Screening Period through Safety Follow-up Visit) while subjects are receiving study drug (Table 9-1). Both ivacaftor and VX-661 are metabolized at least in part via hepatic enzymatic pathway utilizing CYP 3A4, hence the need to restrict usage of known CYP 3A4 inducers and inhibitors.

A nonexhaustive list of study prohibitions and cautions for food and medication will be provided in the Study Reference Manual.

Table 9-1 Study Restrictions

Restricted Medication/Food	Study Period	
	Screening Period	Treatment Period
Certain fruits and fruit juices (Grapefruit, grapefruit juice, Seville oranges, marmalade)	None allowed within 14 days before the first dose of the study drug	None allowed through the Safety Follow-up Visit
Moderate and strong CYP3A inducers	None allowed within 14 days before the first dose of the study drug	None allowed through the Safety Follow-up Visit
Moderate and strong CYP3A inhibitors (except for ciprofloxacin)	None allowed within 14 days before the first dose of the study drug	None allowed through the Safety Follow-up Visit
Commercially available CFTR modulators (e.g., Kalydeco)	None allowed within 30 days before and during screening	None allowed through the Safety Follow-up Visit

CYP: cytochrome P450.

Note: The use of restricted medication by subjects with medical needs will be addressed on a case-by-case basis with the Medical Monitor.

9.4 Prior and Concomitant Medications

Information regarding all prior and concomitant medications, including the subject's CF medications, other medications, and herbal and naturopathic remedies administered from 28 days before the Screening Period through the Safety Follow-up Visit, if applicable, will be recorded in each subject's source documents. For subjects who are screened but are not subsequently randomized into the study, details of prior medication will only be documented in the subjects' source documents.

- Subjects must remain on a stable medication (and supplement) regimen for their CF from 28 days before Day 1 through the Safety Follow-up Visit. Stable medication regimen is defined as the current medication regimen for CF that subjects have been following for at least 28 days before Day 1. Subjects must not initiate long-term treatment with new medication from 28 days before Day 1 through the Safety Follow-up Visit unless discussed and approved by the Vertex Medical Monitor. Guidelines for stable medication regimens for CF are as follows:



- o Subjects who are taking daily inhaled tobramycin or other chronically inhaled antibiotics should remain on that regimen throughout the study.
- o Subjects who are on a stable cycled regimen of a single inhaled antibiotic should continue on this antibiotic throughout the study. The timing of the first dose of study drug should be synchronized described in [Section 8.1.2](#) and [Section 8.1.4](#).
- o Subjects who alternate 2 different antibiotics monthly should remain on the same schedule during the study. To reduce variability, the inhaled antibiotic treatment should be the same and at the same stage through the cycle at the start of each study drug Treatment Period.
- o Subjects may receive doses of prednisone up to 10 mg/day (chronically) or prednisone 60 mg qd for up to 5 days without prior approval of the Medical Monitor.
- Information about bronchodilator use during the study will be collected and documented. Subjects who are using a bronchodilator must have their spirometry assessments performed according to the guidelines provided in [Section 11.6.1](#).
- Concomitant use of medications known to prolong the QT interval should be used with caution during the study, as the effect of VX-661/ivacaftor on the QT interval has not been evaluated in a thorough QT study. Consideration should be given to obtaining an ECG when concomitant medication known to prolong the QT interval is administered.

9.5 Removal of Subjects

Subjects may withdraw from the study at any time at their own request. Subjects may be withdrawn from study drug treatment at any time at the discretion of the investigator or Vertex for safety, behavior, noncompliance with study procedures, or administrative reasons. If a subject has been withdrawn from study drug treatment, the subject should continue to be followed as noted in [Section 8.1.6](#), provided the subject has not withdrawn consent.

If a subject does not return for a scheduled visit, reasonable effort will be made to contact the subject. In any circumstance, reasonable effort will be made to document subject outcome. The investigator will inquire about the reason for withdrawal, request that the subject return all unused investigational product(s), request that the subject return for an ETT and/or Safety Follow-up Visit, if applicable ([Section 8.1.5](#), [Section 8.1.6](#)), and follow up with the subject regarding any unresolved AEs.

If the subject withdraws consent, no further evaluations will be performed, and no additional data will be collected. Vertex may retain and continue to use any data collected before such withdrawal of consent.

The investigator should inquire about the reason for withdrawal of consent.

Subjects must return all unused study drug.

A subject will be withdrawn from study drug treatment for any of the following reasons:

- A female subject or a female partner of a male subject has a confirmed pregnancy.
- A subject's treatment is unblinded by the investigator.

A subject may be withdrawn from study drug treatment after a discussion between the investigator and the Medical Monitor for any of the following reasons:

- A subject develops a medical condition that requires prolonged concomitant therapy with a prohibited medication or prolonged interruption of the study drug.
- A subject develops a life-threatening AE or a serious adverse event (SAE) that places him/her at immediate risk, and discontinuation of study drug treatment and withdrawal from the study are deemed necessary.
- A subject is noncompliant with study requirements.
- A subject has an increase in transaminases (ALT or AST) according to evaluations and management described in [Section 11.7.7](#).
- A subject has an increase in QTc according to evaluations and management described in [Section 11.7.4](#).
- A subject develops a cataract or lens opacity (see [Section 11.7.8](#)).

Subjects who prematurely discontinue study drug treatment should continue to return for assessments as noted in [Section 8.1.6](#).

9.6 Replacement of Subjects

Subjects who withdraw or are withdrawn for nonsafety reasons during the study drug Treatment Periods may be replaced at Vertex's discretion.

10 STUDY DRUG ADMINISTRATION AND MANAGEMENT

Study drug refers to VX-661/ivacaftor, ivacaftor, and their matching placebos.

10.1 Preparation and Dispensing

Study drug may be dispensed only under the supervision of the investigator or an authorized designee and only for administration to the study subjects.

10.2 Administration

Study drug tablets will be administered orally. Subjects will receive the same number of tablets each day to maintain the blind. Refer to [Table 10-1](#).

Table 10-1 Study Drug Administration – Treatment Period

Treatment	Time	Drug(s) and Dose(s) Administered Route of Administration
VX-661/ivacaftor	AM	VX-661 100-mg/IVA 150-mg fixed-dose tablet IVA matching placebo tablet oral
	PM	IVA 150-mg tablet oral
Ivacaftor	AM	VX-661/IVA matching placebo tablet IVA 150-mg tablet oral
	PM	IVA 150-mg tablet oral
Placebo	AM	VX-661/IVA matching placebo tablet IVA matching placebo tablet oral
	PM	IVA matching placebo tablet oral

AM: morning; IVA: ivacaftor; PM: evening.

Study drug should be administered within 30 minutes after starting a meal with fat-containing food, such as a "standard CF" high-fat, high-calorie meal or snack, according to the following guidelines:

1. Study drugs will be administered after the start and before the end of a meal throughout each of the 2 Treatment Periods. It is recommended that the duration of each meal associated with study drug intake (i.e., breakfast and dinner/snack, as applicable) should not exceed 30 minutes.
2. Study drug should be administered q12h (\pm 2 hours). For each subject, all doses (morning and evening) of study drugs will be taken at approximately the same time each day. For example, the morning dose could be taken at 08:00 every morning and the evening dose could be taken at 20:00 every evening throughout the study.
3. At the Day 1 Visit, all subjects will be observed for 6 hours after the morning dose of the study drug.
4. The date, amount taken, and time of study drug administration, including whether food was taken with each dose, will be recorded for 2 days before PK sample collection and on the days of PK sample collection.
5. On days of scheduled visits, the morning dose of study drug will be administered at the site after predose assessments have been completed. The meal or snack will be provided by the site for the morning dose of study drug.

6. If a subject's scheduled visit is to occur in the afternoon, the following guidelines must be used:
 - o If the dose in the clinic will be within 6 hours of the subject's scheduled morning dose, the subject should withhold their morning dose of study drug, and the morning dose will be administered in the clinic.
 - o If the dose in the clinic will be more than 6 hours after the subject's scheduled morning dose, the subject should take the morning dose at home, and the evening dose will be administered in the clinic. In this event, all assessments will be collected relative to the evening dose.
7. For visits after the Day 1 Visit, subjects will be instructed to bring all used and unused study drug to the site; study drug will be dispensed at each visit, as appropriate.
8. At the Week 8 Visit, the morning dose of study drug will NOT be administered. The last dose of study drug will be the evening dose administered the day before the Week 8 Visit.
9. At the Week 24 Visit, the morning dose of study drug will NOT be administered. The last dose of study drug will be the evening dose administered the day before the Week 24 Visit.

10.3 Method of Assigning Subjects to Treatment Groups

Approximately 204 subjects (34 per sequence) will be enrolled and stratified by age at the Screening Visit (<18 versus \geq 18 years of age), FEV₁ severity (determined at the Screening Visit; <70% versus \geq 70% predicted), and type of residual function mutation on the second *CFTR* allele (Class V non-canonical splice mutation versus Classes II to IV residual function mutation; see [Section 16](#)), and then randomized (1:1:1:1:1:1) to 1 of the 6 treatment sequences, as shown in [Section 8.1](#). A minimum of 25% of enrolled subjects will carry a Class II to IV mutation on the second *CFTR* allele (see [Section 16](#)). Enrollment into the non-canonical splice strata will be limited to no more than 75% of total enrollment.

An IWRS will be used to assign subjects to treatment and to ensure enrollment of at least 25% of subject with Class II to IV residual function mutations. Detailed instructions for randomization will be provided separately.

10.4 Dose Modification for Toxicity

The dosage of individual study drugs or the regimen cannot be altered, but the investigator can interrupt or stop treatment with all study drugs.

10.5 Study Drug Interruption

If study drug dosing must be interrupted for more than 72 hours, the Medical Monitor must be notified. In these instances, study drug dosing may only resume after approval by the Medical Monitor. Specific instructions for interruption for elevated LFT levels and elevated QTc levels are provided in [Section 11.7.7](#) and [Section 11.7.4](#), respectively.

10.6 Missed Doses

If a subject misses a dose and recalls the missed dose within 6 hours, the subject should take his/her dose with food. If more than 6 hours have elapsed after his/her usual dosing time, the subject should skip that dose and resume his/her normal schedule for the following dose. For example,

- if the morning dose of study drug should have been taken at approximately 08:00, and the subject remembers at 12:00 that he/she forgot to take his/her dose, he/she should take the dose with food as soon as possible.
- if the morning dose of study drug should have been taken at approximately 08:00, and more than 6 hours have elapsed beyond the scheduled dosing time (i.e., the time is past 14:00), the subject would resume dosing with the evening dose at approximately 20:00.

10.7 Packaging and Labeling

Study drug tablets will be supplied in blister cards by Vertex. Study drug cards will be provided and replaced via the IWRS. A detailed study drug dispensation plan will be provided in the Pharmacy Manual.

Study drug labeling will be in compliance with applicable local and national regulations.

10.8 Study Drug Supply, Storage, and Handling

VX-661/ivacaftor (100 mg/150 mg) and matching placebo will be supplied as light yellow film-coated tablets of similar size and appearance containing VX-661 100 mg/ivacaftor 150 mg and VX-661 0 mg/ivacaftor 0 mg, respectively.

Ivacaftor (150 mg) and matching placebo will be supplied as light blue film-coated tablets of similar size and appearance containing ivacaftor 150 mg and ivacaftor 0 mg, respectively.

Blister cards must be stored at room temperature according to [Table 10-2](#) and to the instructions provided in the Pharmacy Manual. While at the clinical site, the investigator, or an authorized designee (e.g., a licensed pharmacist), will ensure that all investigational products are stored in a secured area, under recommended study conditions, and in accordance with applicable regulatory requirement. To ensure adequate records, all study drugs will be accounted for as detailed in [Section 10.9](#).

Instructions regarding the storage and handling of study drug after dispensation to subjects will be provided to sites in the Pharmacy Manual.

Table 10-2 Identity of Study Drugs, Dosage, and Storage

Drug Name	Strength/Formulation/Route	Dosage	Storage Condition
VX-661/ivacaftor fixed-dose tablet	100-mg/150-mg tablet; oral	100 mg/ 150 mg, morning dose	≤ 25°C (77°F) with excursions to 30°C (86°F)
Ivacaftor	150-mg tablet, oral	150 mg, morning and evening dose	≤ 25°C (77°F) with excursions to 30°C (86°F)
VX-661/ivacaftor matching placebo	0-mg/0-mg tablet; oral	0 mg/ 0 mg, morning dose	≤ 25°C (77°F) with excursions to 30°C (86°F)
Ivacaftor, matching placebo	0-mg tablet, oral	0 mg, morning and evening dose	≤ 25°C (77°F) with excursions to 30°C (86°F)

10.9 Drug Accountability

The pharmacist or designated site staff will maintain records documenting the dates and amounts of

- study drug received,
- study drug dispensed to the subjects, and
- study drug returned by the subjects.

Subjects will be instructed to return all used, partially used, and full study drug blister cards to the site. These materials will be retained at the site according to instructions provided by Vertex or its designee until inventoried by the study monitor. The study monitor will verify study drug records and inventory throughout the study.

10.10 Disposal, Return, or Retention of Unused Drug

The site staff or pharmacy personnel will retain all materials returned by the subjects until the site monitor has performed drug accountability. At the end of the study, the study monitor will provide instructions as to the disposition of any unused investigational product. If the study monitor authorizes destruction at the study site, the investigator will ensure that the materials are destroyed in compliance with applicable environmental regulations, institutional policy, and any special instructions provided by Vertex. Destruction will be adequately documented.

Procedures for the destruction or return of the study drug will be detailed in the Pharmacy Manual.

10.11 Compliance

To ensure treatment compliance, the investigator or designee will supervise all study drug dosing that occurs at the site. At each visit, site personnel will review that the subject is compliant with study drug dosing and remind the subject of study drug dosing requirements. Compliance will also be assessed by ongoing study drug count.

If a subject demonstrates continued noncompliance of study drug dosing despite educational efforts, the investigator should contact the Medical Monitor to discuss discontinuation of the subject from the study treatment.

10.12 Blinding and Unblinding

This is a double-blind study.

10.12.1 Blinding

The subjects and all site personnel, including the investigator, the site monitor, and the study team, will be blinded with the exception of the following:

- Any site personnel for whom this information is important to ensure the safety of the subject in the event of a life-threatening medical emergency
- Any site personnel for whom this information is important to ensure the safety of the subject and their fetus in the event of a pregnancy
- Vertex Global Patient Safety (GPS) and Regulatory Affairs personnel to satisfy SAE processing and reporting regulations
- Unblinded statistician preparing the final (production) randomization list who is not part of the study team
- Vertex Clinical Operations IWRS management
- Vertex Clinical Supply Chain
- IDMC
- Vendor preparing the unblinded analysis for the IDMC
- Vendor analyzing PK samples
- Vertex or vendor conducting the population PK analysis
- Vertex Medical Monitor may, for matters relating to safety concerns, unblind individual subjects at any time

Vertex Drug Metabolism and Pharmacokinetics laboratory personnel will not be involved in the conduct of the study and will be unblinded to the bioanalysis results but will remain blinded to subject number and treatment assignment.

Spirometry Data Blinding

Despite treatment blinding, knowledge of the spirometry results has the potential to suggest whether a subject has been administered active study drug or placebo. Therefore, during the conduct of the study, the Vertex study team will have no access to the post-dose spirometry data. The vendor for central reading of the spirometry data will only send the blinded spirometry files (blinded treatment group, with real values for screening and baseline, but with dummy values for all the spirometry assessments after baseline) to Vertex to be used for developing the statistical programs. Furthermore, subjects and their caregiver should not be informed of their study-related spirometry results during the Treatment Period regardless of whether the subject has prematurely discontinued study drug treatment.

Sweat Chloride Data Blinding

Despite treatment blinding, knowledge of the sweat chloride data has the potential to suggest whether a subject has been administered active study drug or placebo. Therefore, during the conduct of the study, the Vertex study team will have no access to the postdose sweat chloride data; dummy data will be used to develop statistical programs. During the process of locking the clinical database, after all study visits have been completed, access to treatment-blinded sweat chloride data will be provided to a small group of individuals (a biostatistician, a statistical programmer, a validation statistical programmer, and a clinical reviewer) who are not part of the Vertex study team. This small group will review the sweat chloride data to ensure there are no significant data issues and will use the blinded data set to refine the statistical programs.

[REDACTED]

[REDACTED]

[REDACTED]

10.12.2 Unblinding

At the initiation of the study, the study site will be instructed on the method for breaking the blind. The unblinding method will be either a manual or an electronic process.

Unblinding of the individual subject's treatment by the investigator will be limited to medical emergencies or urgent clinical situations in which knowledge of the subject's study treatment is necessary for clinical management. In such cases, investigators will use their best judgment as to whether to unblind without first attempting to contact the Medical Monitor to discuss and agree to the need for unblinding. If investigators deem it not necessary to unblind immediately, they will first attempt to contact the Medical Monitor to discuss and agree to the need for unblinding. If investigators have tried but are unable to reach the Medical Monitor, they will use their best judgment, based on the nature and urgency of the clinical situation, and may proceed with unblinding without having successfully reached and discussed the situation with the Medical Monitor.

Contact information for the Medical Monitor (or appropriate backup) will be provided in a separate document.

In addition, the Vertex Medical Information Call Center [REDACTED] will answer calls 24 hours a day, 7 days a week, 365 days of the year, and will triage these calls to the study Medical Monitor or appropriate backup.

If a subject's treatment assignment has been unblinded for a medical emergency or urgent clinical situation, the Medical Monitor will be notified within 24 hours of the unblinding event. The reason and the date of the unblinding will be documented clearly in the subject's study file. Information about the treatment assignment obtained from the unblinding will be maintained in a secure location with controlled access and will not be shared with the sponsor (Vertex), contract research organization (CRO), or any site personnel (other than the physician treating the subject). In addition, the investigator will consider whether the clinical event that prompted unblinding will be considered an SAE, according to the regulatory definitions or criteria for SAEs, and if so, submit an SAE report to Vertex GPS or designee, per [Section 13.1.2](#).

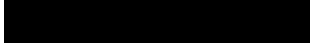
Vertex GPS or designee will also unblind any SAE reports in compliance with regulatory reporting requirements. In addition, Vertex may, for matters relating to safety concerns, unblind individual subjects at any time.

11 ASSESSMENTS

11.1 Timing of Assessments

The timing of assessments is shown in [Table 3-1](#) and [Table 3-2](#).

The CFQ-R questionnaire must be performed before any other assessment at the clinic visits when it is required. For the remaining assessments, the following assessments must be performed in the following order when more than 1 assessment is required at a particular time point:

- 
2. standard 12-lead ECG recordings
 3. vital signs and pulse oximetry
 4. spirometry
 5. sweat chloride
 6. safety laboratory assessments (including blood draws)
 7. PK sampling

Note: if study drug is not administered on the day of the visit (for any reason, including study drug interruption or premature discontinuation of study drug), only 1 set of assessments will be collected ([Table 3-2](#)).

11.1.1 Informed Consent/Assent

Each subject of age of consent (per local requirements) must sign and date a study-specific ICF before any study-specific procedures can be performed. Subjects not of age of consent must assent, if applicable per local requirements, to participate in the study, and the subject's parent or legal guardian must sign and date a study-specific ICF before any study-specific procedures can be performed. The consent forms will comply with all applicable regulations governing the protection of human subjects. An ICF and Assent Form, approved by Vertex and the site's institutional review board (IRB) or ethics committee (EC), must be used.

11.1.2 Assigning Subject Number

Once a subject has signed an ICF or Assent Form, if applicable, a subject number will be assigned. The subject will retain this number for the entire study. Detailed instructions on assigning subject numbers will be provided in the Study Reference Manual. If a subject is rescreened, the subject retains the original subject number.

11.2 Subject and Disease Characteristics

Subject and disease characteristics include the following: demographics, medical history, height, and weight.

Medical history will be elicited from each subject during screening. Based on the medical history, the subject will be assessed for any disqualifying medical conditions as specified in the inclusion and exclusion criteria. The medical history shall include a complete review of systems, past medical and surgical histories, and any allergies.



11.3 Total Blood Volume

Total blood volume will be outlined in the laboratory manual.

11.4 Pharmacokinetics

11.4.1 Blood Sampling

Blood samples will be collected as shown in [Table 3-1](#) and [Table 3-2](#).

At the visits and time points indicated in [Table 3-2](#), blood samples will be collected for the determination of the concentrations of VX-661, M1-661, ivacaftor, and M1-ivacaftor. Blood samples collected before dosing must be collected within 60 minutes before dosing.

Samples from the PK sampling will be kept frozen by Vertex or its designee until all analyses have been completed and then disposed of according to Vertex or designee SOPs.

For each visit with a PK blood draw, a record of study drug administration will be collected as described in [Section 10.2](#). The collection date and time that each PK blood sample is drawn will also be recorded.

Details on sample collection, processing, and shipping will be provided in a separate protocol-specific Laboratory Manual.

11.4.2 Processing and Handling of Pharmacokinetic Samples

Detailed procedures for the collection of blood samples and further procedures for the processing and handling of samples for PK analysis will be provided in the Laboratory Manual. The shipment address and assay laboratory contact information will be provided to the investigational site before initiation of the study.

11.4.3 Bioanalysis

Samples will be analyzed using a validated analytical method in compliance with Vertex or designee SOPs. A description of the assay methods and validation data will be provided in separate reports.

If appropriate, these samples may also be used for evaluations of metabolites of VX-661 and ivacaftor during treatment. These samples may also be used for further evaluation of the bioanalytical method and for analyses that provide information on the metabolic pathways used or impacted by VX-661 and ivacaftor. These data will be used for exploratory purposes and may not be included in the clinical study report.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

11.6 Efficacy

11.6.1 Spirometry

Spirometry will be performed according to the ATS/ERS guidelines²⁹ at the time points noted in [Table 3-1](#) and [Table 3-2](#) according to the additional guidelines that follow.

Prebronchodilator spirometry is defined as spirometry testing performed for subjects who have

- withheld their short-acting bronchodilators (e.g., albuterol) or anticholinergic (e.g., ipratropium bromide [Atrovent[®]]) for more than 4 hours before the spirometry assessment
- withheld their long-acting bronchodilator (e.g., salmeterol) for more than 12 hours before the spirometry assessment; and
- withheld their once-daily, long-acting bronchodilator (e.g., tiotropium bromide [Spiriva[®]]) for more than 24 hours before the spirometry assessment

During the Treatment Periods, spirometry assessments must be performed before dosing. In adolescent subjects (< 18 years of age at the Screening Visit), additional postdose spirometry assessments on Day 1 of each Treatment Period (Week 1 and Week 17) and Day 15 of each Treatment Period (Week 2 and Week 18) will be collected at 2 and 4 hours after the morning dose. A window of ± 15 minutes will be allowed around the nominal times for all postdose spirometry assessments.

During the Screening Period, spirometry assessments may be performed pre- or post-bronchodilators. At all the other visits, all spirometry assessments should be performed “prebronchodilator.”

In the event that a subject forgets to withhold bronchodilator(s), spirometry should be performed according to the following:

- If a subject’s Day 1 (Treatment Period 1) spirometry is prebronchodilator, but, on a subsequent visit, the subject does not withhold bronchodilator use, a postbronchodilator spirometry will be obtained for that visit only, and the visit will not be rescheduled.

- If, on Day 1 (Treatment Period 1), the subject does not withhold his/her dose of bronchodilator, spirometry should be performed postbronchodilator, and all subsequent spirometric measurements (according to the schedule of assessments detailed in [Table 3-2](#)) should be performed postbronchodilator.
- For visits with postdose spirometry assessments (Weeks 1, 2, 17, and 18), if the predose spirometry is performed postbronchodilator, the subject should withhold any further bronchodilator use until completion of the 4-hour postdose spirometry assessment on that day.
- Each spirometry assessment will be recorded in the source documents as pre- or postbronchodilator.

All sites will be provided with spirometers to be used for all study assessments. Spirometry data will be transmitted to a centralized spirometry service for quality review.

Subjects and their parent/caregiver should not be informed of their study-related spirometry results from Day 1 through Week 24, regardless of whether the subject prematurely discontinues treatment.

The parameters listed below will be normalized using the standards of Wang et al⁴⁴ (for female subjects aged 12 to 15 years [inclusive] and male subjects aged 12 to 17 years [inclusive]) or Hankinson et al⁴³ (for female subjects aged 16 years and older and male subjects aged 18 years and older):

- FEV₁ (L)
- Forced vital capacity (FVC) (L)
- FEV₁/FVC (ratio)
- Forced expiratory flow 25% to 75% (FEF_{25%-75%}) (L/s)

11.6.2 Sweat Chloride Testing

The sweat chloride test is a standard diagnostic tool for CF, serving as a biomarker of CFTR activity. Collection of sweat samples will be performed at visits specified in [Table 3-1](#) and [Table 3-2](#), using an approved collection device. Sweat samples will be sent to a central laboratory for testing and interpretation of results. Individual sweat chloride test results will not be disclosed to the study sites. Specific instructions for collection, handling, processing, and shipping of sweat chloride samples to the central laboratory will be provided separately.

The sweat collection on dosing visits should occur approximately 1 hour before the PK sample collection and before the morning dose of the study drugs. At each time point, 2 samples will be collected, 1 from each arm (left and right).

Sweat collection must be performed at the Screening Visit if the sweat chloride value is not available in the subject's medical record. For subjects using a sweat chloride value documented in their medical record to establish eligibility, the sweat chloride test at the Screening Visit is optional. Collection of sweat chloride will not overlap with any other study assessments.

11.6.3 Cystic Fibrosis Questionnaire-Revised

Subjects will be asked to complete the CFQ-R in their native language.^{34,49} The CFQ-R will be completed before the start of any other assessments, as noted in [Table 3-1](#) and [Table 3-2](#). Subjects who are 12 and 13 years of age at Day 1 will complete the CFQ-R Child version themselves, and their parents/caregivers will complete the CFQ-R Parent version, at all visits, regardless of whether the subject subsequently turns 14 years of age during the study. Subjects 14 years of age and older at Day 1 will complete the Adolescent/Adult version of the questionnaire themselves at all visits. The questionnaires provide information about demographics; general quality of life, school, work, or daily activities; and symptom difficulties (pertaining to CF). Copies of the CFQ-R used in this study will be provided in the Study Reference Manual. Validated translations^{35,36} of the CFQ-R, if available, will be provided for participating centers in non-English-speaking countries.

[REDACTED]

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11.7 Safety

Safety evaluations will include AEs, clinical laboratory assessments, clinical evaluation of vital signs, ECGs, pulse oximetry, and PEs.

11.7.1 Adverse Events

All AEs will be assessed, documented, and reported in accordance with ICH GCP guidelines. [Section 13.1](#) outlines the definitions, collection periods, criteria, and procedures for documenting, grading, and reporting AEs. A separate document that details AE electronic case report form (eCRF) completion guidelines for investigators as well as training will be provided.



11.7.2 Clinical Laboratory Assessments

Blood and urine samples will be analyzed at a central laboratory, with the exception of urine pregnancy tests, which will be performed and analyzed at the site. Blood samples requiring a 4-hour fast will be collected on Day 1, Week 8, Week 17, Week 24, and the ETT Visit. Fasting is not required at other time points unless specified in the assessment table. On Day 1 and Week 17 Visit, blood samples will be collected before the first dose of the study drug. At all the other scheduled visits, these samples will be collected at any time during the visit, relative to the order of assessments indicated in [Section 11.1](#) and according to the schedule in [Table 3-1](#) and [Table 3-2](#).

Blood and urine samples for clinical laboratory assessments will be collected as shown in [Table 3-1](#) and [Table 3-2](#). Laboratory test results that are abnormal and considered clinically significant will be reported as AEs (see [Section 13.1.1](#)).

The safety laboratory test panels are shown in [Table 11-1](#).



Table 11-1 Safety Laboratory Test Panels

Serum Chemistry	Hematology	Urinalysis ^a
Glucose	Hemoglobin	Leukocyte esterase
Blood urea nitrogen	Erythrocytes	Nitrite
Creatinine	Mean corpuscular hemoglobin	Urobilinogen
Sodium	Mean corpuscular hemoglobin concentration	Urine protein
Potassium	Mean corpuscular volume	pH
Calcium	Reticulocytes	Urine blood
Chloride	Platelets	Specific gravity
Magnesium	Leukocytes	Urine ketones
Bicarbonate	Differential (absolute and percent):	Urine bilirubin
Inorganic phosphate	Eosinophils	Urine glucose
Total bilirubin, direct bilirubin	Basophils	
Alkaline phosphatase	Neutrophils	
Aspartate aminotransferase	Lymphocytes	
Alanine aminotransferase	Monocytes	
Lactate dehydrogenase	Coagulation Studies	
Gamma-glutamyl transpeptidase	Activated partial thromboplastin time	
Total protein	Prothrombin time	
Albumin	Prothrombin time International Normalized Ratio	
Creatine kinase		
Amylase		
Lipase		
Vitamin Levels		
Vitamins A, D, E, K, and B12		
Lipid Panel		
Total cholesterol		
Triglycerides		
Low-density lipoprotein		
High-density lipoprotein		

^a If urine is positive for leukocyte esterase, nitrite, protein, or blood, microscopic examination of urine will be performed for leukocytes, erythrocytes, crystals, bacteria, and casts.

Pregnancy (β-human chorionic gonadotropin) Tests for Females of Childbearing Potential: Serum samples will be obtained as specified in [Table 3-1](#) and [Table 3-2](#) and analyzed at the central laboratory. Urine pregnancy tests will be performed at the site as specified in [Table 3-2](#). The urine pregnancy test on Day 1 must be negative before the first dose of study drug.

FSH (Screening Period only): Blood sample for FSH will be measured for any potentially postmenopausal female with at least 12 months of continuous spontaneous amenorrhea. Serum FSH levels must be ≥40 mIU/mL to be considered postmenopausal.

CFTR Genotype (Screening Period only): CFTR genotyping will be performed on all subjects. Refer to the Laboratory Manual to determine the appropriate genotyping assay for each subject.



Additional Evaluations: Additional clinical laboratory evaluations will be performed at other times if judged to be clinically appropriate.

For purposes of study conduct, only laboratory tests done in the central laboratory may be used. At the discretion of the local investigator, local laboratories may be used for management of urgent medical issues. If a local laboratory test value is found to be abnormal and clinically significant, it should be verified by the central laboratory as soon as possible after the investigator becomes aware of the abnormal result. If it is not possible to send a timely specimen to the central laboratory (e.g., the subject was hospitalized elsewhere), the investigator may base the assessment of an AE on the local laboratory value.

11.7.3 Physical Examinations and Vital Signs

A PE of all body systems and vital signs assessment will be performed at screening and select study visits (see [Table 3-1](#) and [Table 3-2](#)). At other visits, symptom-directed PEs and symptom-directed vital sign assessments can be performed at the discretion of the investigator or healthcare provider.

A PE includes a review of the following systems: head/neck/thyroid, eyes/ears/nose/throat (EENT), respiratory, cardiovascular, lymph nodes, abdomen, skin, musculoskeletal, and neurological. Breast, anorectal, and genital examinations will be performed when medically indicated. After screening, any clinically significant abnormal findings in PEs will be reported as AEs.

Vital signs include blood pressure (systolic and diastolic), oral temperature, pulse rate, and respiration rate. These will be assessed following a 5-minute rest in the seated or supine position.

11.7.4 Electrocardiograms

Standard 12-lead ECGs will be performed using a machine with printout according to the Schedule of Assessments ([Table 3-1](#) and [Table 3-2](#)). A window of ± 15 minutes will be allowed around the nominal times for all postdose ECG assessments. Additional standard 12-lead ECGs will be performed at any other time if clinically indicated.

The performance of all ECGs will adhere to the following guidelines:

- The subject will be instructed to rest in the supine position for at least 5 minutes before having an ECG performed.
- The ECG will be performed before any other procedures that may affect heart rate (HR), such as blood draws.

The ECG traces will be manually read at the study site at the Screening and Safety Follow-up Visits. A printout of the ECG traces will be made for safety review by the investigator and maintained with source documentation. Clinically significant ECG abnormalities occurring during the study through the Safety Follow-up Visit will be recorded as AEs.

To ensure safety of the subjects, a qualified individual at the study site will make comparisons to baseline measurements. If the QTcF is increased by >45 msec from the baseline or an absolute QTcF value is ≥ 500 msec for any scheduled ECG, 2 additional ECGs will be performed approximately 2 to 4 minutes apart to confirm the original measurement. If

either of the QTcF values from these repeated ECGs remains above the threshold value (>45 msec from baseline or ≥ 500 msec), a single ECG will be repeated at least hourly until QTcF values from 2 successive ECGs fall below the threshold value that triggered the repeat measurement.

If the QTcF value remains above the threshold value (>45 msec from the average of the 3 predose values on Day 1 or ≥ 500 msec) on repeated measurement or is noted on >2 occasions with no identified alternative etiology for the increased QTcF study drug, then discontinuation from study drug treatment may be required after discussion with the Medical Monitor.

Subjects who discontinue study drug treatment for increased QTc should have their QTc monitored closely until it normalizes or returns to baseline.

11.7.5 Contraception and Pregnancy

11.7.5.1 Contraception

The effects of VX-661 monotherapy or in combination with ivacaftor on conception, pregnancy, and lactation in humans are not known. Neither VX-661 nor ivacaftor showed any genotoxic potential in a standard battery of in vitro (Ames test, Chinese hamster ovary cell chromosomal aberration) and in vivo (mouse micronucleus) studies. VX-661 and ivacaftor were each found to be nonteratogenic in reproductive toxicology studies in rats and rabbits.^{27,28} Subjects should follow the contraception requirements outlined in this study protocol. The effects of VX-661 monotherapy or in combination with ivacaftor on the PK of hormonal contraceptives are not known. Thus, hormonal contraception is not an acceptable method of contraception for female subjects though it is acceptable for the female partners of male subjects.

At this stage in the development of VX-661 in combination with ivacaftor, participation in this study requires a commitment from the research subject and his/her partner to use at least 1 effective method of birth control. Acceptable methods of contraception for participants of this study and their partners are listed below. Methods of contraception should be in successful use from signing of consent, approximately 28 days, before the first dose of study drug (unless otherwise noted) and until 90 days following the last dose of study drug.

Contraception for the couple is waived for the following:

- True abstinence for the subject, when this is in line with the preferred and usual lifestyle of the subject. Periodic abstinence (e.g., calendar, ovulation, symptothermal, and postovulation methods) and withdrawal are not acceptable methods of contraception.
- If the male is infertile (e.g., bilateral orchiectomy). Infertility may be documented through examination of a semen specimen or by demonstration of the absence of the vas deferens by ultrasound or medical record before the first dose of the study drug.
- If the female is of non-childbearing potential, per the following:
 - o Postmenopausal: spontaneous amenorrhea for at least 12 consecutive months and serum FSH level ≥ 40 mIU/mL at Screening
 - o Documented hysterectomy or a bilateral oophorectomy/salpingo-oophorectomy

- o Has not achieved menarche (has not had her first menstrual period). Females who fall into this category are considered not to be of childbearing potential only as long as they have not had their first menstrual period. If a female achieves menarche during the study, she will need to provide consent for compliance (proper method of contraception or abstinence).
- NOTE: All other female subjects who have had their first menstrual period will be considered to be of childbearing potential.

Acceptable contraceptive methods:

Acceptable contraceptive methods for **male subjects** or **male partners** of female subjects include the following:

- Vasectomy 6 months or more previously, with a documented negative postvasectomy semen analysis for sperm.
- Condom and spermicide.
 - o In countries where spermicide is not available, condom without spermicide will be considered acceptable.
 - o Local regulations may require use of an additional acceptable method of contraception.

Acceptable contraceptive methods for **female subjects** include the following:

- Bilateral tubal ligation performed at least 6 months previously.
- Continuous use of an intrauterine device (non-hormone-releasing) for at least 90 days before the first dose of study drug.
- Barrier contraception (such as diaphragm, cervical cap, or female condom) and spermicide.
 - o In countries where spermicide is not available, barrier contraception without spermicide will be considered acceptable.
 - o Local regulations may require use of an additional acceptable method of contraception.
- NOTE: Hormonal contraceptives will not be considered as an effective method; however, female subjects are not required to discontinue hormonal contraceptives.

Acceptable contraceptive methods for **female partners** of male subjects:

- Bilateral tubal ligation performed at least 6 months previously.
- Continuous use of an intrauterine device for at least 90 days before first dose of study drug.
- Barrier contraception (such as diaphragm, cervical cap, or female condom) and spermicide.



- o In countries where spermicide is not available, condom without spermicide will be considered acceptable.
- o Local regulations may require use of an additional acceptable method of contraception.
- Hormonal contraceptives, if successfully used for at least 60 days before first dose of study drug.

Additional notes:

- Acceptable methods of contraception listed above are examples. Local requirements may prohibit the use of some of these examples. Please contact the Medical Monitor with any questions.
- A female condom cannot be used with a male condom (as a double method of contraception) due to risk of tearing.
- Male and female subjects who are not sexually active at the time of screening must agree to follow the contraceptive requirements of this study if they become sexually active with a partner of the opposite sex.
- If applicable, additional contraception requirements may need to be followed according to local regulations and/or requirements.
- Male subjects must not donate sperm after the first dose of study drug, throughout the study, and for 90 days following the last dose of study drug.
- Female subjects and female partners of male subjects should not plan to become pregnant during the study through 90 days following the last dose of study drug.
- Male subjects whose female partner becomes pregnant through well-documented in vitro fertilization (donated sperm) or banked sperm (collected before the subject received study drug) must be compliant with the contraception requirements. In this scenario, the male subject and his female partner must commit to using barrier methods of contraception (to ensure there is no exposure of the fetus to study drug) for the duration of the study and until 90 days after the last dose of study drug.
- Female subjects should not nurse a child from the start of study drug dosing through 90 days following the last dose of study drug.
- Unique situations that may not fall within the above specifications should be discussed with the Medical Monitor.

11.7.5.2 Pregnancy

Subjects will be counseled to inform the investigator of any pregnancy that occurs during study treatment and within 90 days after the last dose of the study drug.

If a female subject or the female partner of a male subject becomes pregnant while participating in the study, study drug must be permanently discontinued immediately. For male subjects, study drug does not need to be permanently discontinued if the female partner's pregnancy resulted from donated sperm or sperm banked before study drug

exposure ([Section 11.7.5.1](#)). The investigator must notify the Medical Monitor and Vertex GPS within 24 hours of the site's knowledge of the subject's (or partner's) pregnancy using the Pregnancy Information Collection Form.

If the subject is confirmed to be on study drug, the subject or partner will be followed until the end of the pregnancy, and the infant will be followed for 1 year after the birth, provided informed consent is obtained. A separate ICF will be provided to explain these follow-up activities. Pregnancy itself does not constitute an AE.

11.7.6 Pulse Oximetry

Arterial oxygen saturation by pulse oximetry will be measured at visits noted in [Table 3-1](#) and [Table 3-2](#). This will be assessed following a 5-minute rest (seated or supine) and before study drug dosing. At visits when study drug is taken at the site, pulse oximetry will be collected before the morning dose. This is a noninvasive measure of oxygen delivery to the tissues and has been correlated with clinical status and lung function.

11.7.7 Liver Function Test Parameters

Liver Function Testing

Liver function testing (ALT, AST, GGT, ALP, direct bilirubin, and total bilirubin) must be performed as noted in [Table 3-2](#) for serum chemistry, while subjects are receiving study drug treatment and at the Safety Follow-up Visit.

These blood samples should be processed and shipped immediately per the Laboratory Manual.

Subjects with new treatment-emergent ALT or AST elevations of $>3 \times \text{ULN}$ and clinical symptoms must be followed closely, including repeat confirmatory testing performed by the central laboratory within 48 to 72 hours of the initial finding and subsequent close monitoring of ALT and AST levels, as clinically indicated. In addition, if ALT or AST is $>5 \times \text{ULN}$, repeat follow-up levels must be obtained within 7 ± 2 days.

If a subject cannot return to the site for liver function testing, a local laboratory may be used. Elevations in LFTs at the local laboratory must be reported immediately to the Medical Monitor, and the subject must have the tests repeated and sent to the central laboratory as soon as possible (ideally within 48 to 72 hours).

Study Drug Interruption

Study drug administration **must be interrupted** immediately (prior to confirmatory testing), and the Medical Monitor must be notified, if any of the following criteria is met and confirmed with repeat testing:

- ALT or AST $>8 \times \text{ULN}$
- ALT or AST $>5 \times \text{ULN}$ for more than 2 weeks
- ALT or AST $>3 \times \text{ULN}$, in association with total bilirubin $>2 \times \text{ULN}$ and/or clinical jaundice

A thorough investigation of potential causes should be conducted, and the subject should be followed closely for clinical progression.

If no convincing alternative etiology (e.g., acetaminophen use, viral hepatitis, or alcohol ingestion) for the elevated transaminases is identified, regardless of whether ALT or AST levels have improved, study drug treatment must be permanently discontinued if repeat testing within 48 to 72 hours confirms the initial elevation. Subjects in whom treatment is discontinued for elevated transaminases should have their transaminases monitored closely until levels normalize or return to baseline.

Resumption of Study Drug

If an alternative, reversible cause of transaminase elevation has been identified, study drug may be resumed once transaminases return to baseline or are $\leq 2 \times$ ULN, whichever is higher. Approval of the Medical Monitor is required before resumption of study drug. Upon resumption of study drug, transaminases should be assessed weekly for 4 weeks. If a protocol-defined transaminase elevation occurs within 4 weeks of rechallenge with the study drug (with confirmation of the initial elevation by repeat testing within 48 to 72 hours), then the study drug treatment must be permanently discontinued, regardless of the presumed etiology.

11.7.8 Ophthalmologic Examination

Subjects will undergo an ophthalmologic examination performed by a licensed ophthalmologist at Screening, which includes

- measurement of best corrected distance visual acuity of each eye
- measurement of lens refracting power following cycloplegia (e.g., autorefractor or ophthalmoscopy streak)
- pharmacologically dilated examination of the lens with a slit lamp

The screening ophthalmologic examination must be completed and the results reviewed before randomization. This examination does not have to be repeated if there is documentation of an examination that met protocol criteria and that was within 3 months before the start of the Screening Period. Subjects who have documentation of bilateral lens removal do not need the ophthalmologic examination.

If a cataract, lens opacity, Y-suture, or lamellar rings are identified and determined to be clinically significant by the ophthalmologist at the Screening examination, the subject is ineligible for study entry (see [Section 9.2](#)). If a cataract or lens opacity is identified and determined to be clinically significant by the ophthalmologist after dosing, the subject and Vertex Medical Monitor will be notified. After discussion with the Principal Investigator who collaborates with the Vertex Medical Monitor, the subject may elect to continue or discontinue study drug treatment. If the subject discontinues study drug treatment, the subject should complete the ETT and Safety Follow-up Visit (see [Section 8.1.6](#)). If the subject continues study drug treatment, more frequent ophthalmologic monitoring should be considered.

In addition to the screening examination, an ophthalmologic examination will be performed by a licensed ophthalmologist at the Safety Follow-up Visit or ETT Visit for the following subjects:

- subjects < 18 years of age at the Screening Visit who prematurely discontinue treatment after receiving at least 1 dose of study drug,
- subjects < 18 years of age at the Screening Visit who complete study drug treatment but do not enroll in a separate extension study of VX-661/ivacaftor within 28 days after the last dose of study drug.

This examination may be completed at either the ETT or Safety Follow-up Visit, but must be completed by the date of the Safety Follow-up Visit. Additional ophthalmologic examinations may be conducted at the discretion of the investigator. The Medical Monitor should be notified of any additional ophthalmologic examinations.

Subjects who have documentation of bilateral lens removal are not required to complete the eye examination at the Safety Follow-up Visit or ETT Visit.

In addition, at Screening, the following history will be obtained for all subjects:

- history of steroid use
- history or presence of diabetes
- any prior ophthalmologic or optometric examinations
- history of trauma to the eye
- any family history of glaucoma, congenital cataracts, or cataracts arising later in life
- use of corrective lenses (contact lenses or eyeglasses)
- history of prolonged exposure to sunlight or ultraviolet light and use of sunglasses
- history of exposure to secondhand smoke

12 STATISTICAL AND ANALYTICAL PLANS

This section presents a summary of the planned analyses for this protocol. Statistical analysis details will be provided in the Statistical Analysis Plan (SAP), and clinical pharmacologic analysis details will be provided in the Clinical Pharmacology Analysis Plan (CPAP), both of which will be finalized before the clinical data lock for the study and treatment unblinding.

12.1 Sample Size and Power

The primary efficacy endpoint is the absolute change in percent predicted FEV₁ from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period.

The null hypotheses to be tested are that the mean change from study baseline in percent predicted FEV₁ to the average of the Week 4 and Week 8 measurements is the same for (i) VX-661/ivacaftor and placebo; and (ii) ivacaftor monotherapy and placebo.

Assuming a standard deviation (SD) of 7 percentage points, 30 subjects per sequence are needed to have at least 90% power to detect a 3 percentage point treatment difference between VX-661/ivacaftor and placebo when the mean values of the primary endpoint are being compared. A 2-sided significance level of 0.05 was used in the sample size calculations. Accounting for the hierarchical testing strategy, the proposed sample size will yield approximately an 85% chance of observing a statistically significant difference between ivacaftor monotherapy and placebo for the primary endpoint, under the assumption that ivacaftor monotherapy is also 3 percentage points better than placebo (refer to [Section 12.3.3.2](#) for a detailed description of the testing strategy). The sample size estimate was based on 10,000 simulation runs with an incomplete block design assuming no dropouts. In the simulation, the correlation between responses to the 2 treatments within a subject was assumed to be zero. After adjusting for an assumed dropout rate of 10%, the sample size was increased to 34 subjects per sequence (204 total subjects).

12.2 Analysis Sets

Assignment of subjects to analysis sets will be done before the clinical data lock for the study.

The All Subjects Set is defined as all subjects who were randomized or dosed (i.e., all subjects in the study). All subject data listings will be referenced using the All Subjects Set, unless otherwise specified.

The Full Analysis Set (FAS) is defined as all randomized subjects who carry the intended *CFTR* mutations (see [Section 16](#)) and who have received at least 1 dose of study drug. The FAS is to be used in efficacy analyses in which subjects will be analyzed according to the treatment to which they were assigned or according to the treatment sequence to which they were randomized. All analyses of background data and efficacy data will be based on the FAS.

The Safety Set is defined as all subjects who received at least 1 dose of study drug. The Safety Set is to be used for all safety analyses in which subjects will be analyzed according to the treatment they received. All analyses of safety data will be based on the Safety Set.

12.3 Statistical Analysis

The primary objective of this study is to evaluate the efficacy of VX-661/ivacaftor and ivacaftor monotherapy through 8 weeks of treatment in subjects with CF who are heterozygous for the *F508del* mutation on the *CFTR* gene and a second allele with a *CFTR* mutation predicted to have residual function.

This section presents a summary of the planned statistical analyses of efficacy and safety for this study. The Vertex Biometrics department or a designated CRO will analyze the data derived from this study. SAS[®] Version 9.2 or higher will be used to generate all statistical outputs (tables, figures, listings, and data sets).

Statistical analysis and presentation details will be provided in the SAP for the study.

12.3.1 General Considerations

All individual subject data for those randomized or exposed to study drug will be presented in data listings.

Continuous variables will be summarized using the following descriptive summary statistics: number of subjects (n), mean, SD, standard error (SE), median, minimum value (min), and maximum value (max). The precision of the measurement for each continuous variable will be specified in the SAP.

Categorical variables will be summarized using counts and percentages. Percentages will be presented to 1 decimal place.

Treatment emergent (TE) period for Treatment Period 1 will correspond to data from the first dose of study drug in the first period to the safety evaluation visit or 28 days after the last dose in the same period for subjects who do not have a safety evaluation visit. Similarly, TE period for Treatment Period 2 will correspond to data from first dose of study drug in the second period through the Safety Follow-up Visit or 28 days after the last dose in the same period for subjects who do not have an Safety Follow-up Visit.

Baseline: For this crossover study, 2 types of baseline will be defined. The **study baseline** is defined as the most recent nonmissing measurement (scheduled or unscheduled) collected prior to the first dose of study drug in the study. The definition will be applied to all demographics, background, and baseline characteristics and also efficacy data analysis, including the primary endpoint analysis. In addition, **period baseline** is defined as the most recent nonmissing measurement (scheduled or unscheduled) collected before the first dose of study drug in each Treatment Period. For Treatment Period 2, the baseline should be from an assessment measured after the TE period for Treatment Period 1. This definition will be applied to all safety data analysis. For ECG, baseline for Period 1 will be defined as the average of the 3 pretreatment measurements on Day 1. For sweat chloride, the study baseline value will be the mean of assessment values on the left and the right arm at the most recent time point before the first dose of study drug in the study.

Absolute change from study baseline will be calculated as post-baseline value – study baseline value.

Relative change from study baseline will be calculated as $100 \times (\text{post-baseline value} - \text{study baseline value}) / \text{study baseline value}$.

Absolute change from period baseline will be calculated as post-baseline value – period baseline value.

Relative change from period baseline will be calculated as $100 \times (\text{post-baseline value} - \text{period baseline value}) / \text{period baseline value}$.

12.3.2 Background Characteristics

Subject disposition, demographic and baseline characteristics, prior and concomitant medications, study drug exposure and compliance, and other background characteristics will be summarized. Additionally, all subject data will be presented in subject data listings. All

summaries will be based on the FAS unless otherwise specified in the SAP for the study. No statistical hypothesis testing will be performed on background characteristics.

12.3.2.1 Subject Disposition

Number and percentage of subjects in the following categories will be summarized by treatment sequence:

- All Subjects Set
- All Randomized
- Safety Set
- FAS: Subjects who are randomized and dosed and carry the intended *CFTR* mutations (see [Section 16](#))

The number and percentage (based on the FAS) of subjects in each of the following disposition categories will be presented:

- Completed study drug treatment
- Prematurely discontinued study drug treatment and the reasons for discontinuation
- Last scheduled on-treatment visit completed for subjects who discontinued study drug treatment
- Completed study
- Prematurely discontinued the study and the reasons for discontinuation
- Prematurely discontinued the study during the Treatment Period and the reasons for discontinuation
- Last scheduled visit completed
- Rolled over to extension study

12.3.2.2 Demographics and Baseline Characteristics

Demographic, background (e.g., medical history), and baseline characteristics will be summarized by treatment sequence. Protocol deviations/violations will be provided as a subject data listing only. Important protocol deviations/violations will be summarized.

The following demographics and study baseline characteristics will be summarized by treatment sequence for the FAS: sex, race, ethnicity, age, weight, height, body mass index (BMI), region, study baseline percent predicted FEV₁, study baseline sweat chloride, and study baseline score of CFQ-R respiratory domain.

12.3.2.3 Prior and Concomitant Medications

Medications used in this study will be coded by using the World Health Organization Drug Dictionary Enhanced and categorized as follows:

- **Prior medication:** any medication that started before the first dose of study drug, regardless of when it ended.
- **Concomitant medication:** medication continued or newly received during the TE period for Treatment Period 1 or Treatment Period 2. If a subject took a medication during a specific Treatment Period, this medication will be attributed to the treatment the subject received during this Treatment Period. As a result, 1 medication could be attributed to more than 1 treatment.
- **Post-treatment medication:** medication continued or newly received beyond the TE period for Treatment Period 2, or between the TE periods for Treatment Period 1 and Treatment Period 2, or beyond the TE period for Treatment Period 1 for subjects who do not participate in Treatment Period 2.

A given medication can be classified as a prior medication, a concomitant medication, or a post-treatment medication; both prior and concomitant; both concomitant and post-treatment; or prior, concomitant, and post-treatment. If a medication has a missing or partial missing start/end date or time and it cannot be determined whether the medication was taken before initial dosing, concomitantly, or post-treatment, it will be considered as prior, concomitant, and post-treatment.

Prior medications will be summarized by treatment sequence, and concomitant medications will be summarized by treatment based on the FAS. Post-treatment medications will be listed for each subject.

12.3.2.4 Study Drug Exposure and Compliance

Exposure to study drug (i.e., duration of treatment) will be summarized by treatment for the FAS in terms of duration of treatment a subject received (in days), defined as the last day minus the first day of study drug plus 1 within the Treatment Period.

Study drug compliance will be calculated as follows:

$$100 \times [1 - (\text{Total number of days study drug interrupted}) / (\text{Duration of study drug exposure})].$$

The total number of days of study drug interrupted is defined as the sum of (number of days of study drug interrupted in each interruption interval); where number of days of study drug interrupted in each interval is defined as the interruption end date - the corresponding interruption start date + 1.

Duration of treatment and study drug compliance will be summarized by means of descriptive summary statistics.

12.3.3 Efficacy Analysis

The primary objective of this study is to evaluate the efficacy of VX-661/ivacaftor and ivacaftor monotherapy. For efficacy analysis, the statistical inference will be based on change from study baseline. A hierarchical testing strategy will be used to preserve the overall type I error rate at the 0.05 level.

12.3.3.1 Analysis of Primary Variables

The primary efficacy endpoint is the absolute change in percent predicted FEV₁ from study baseline to the average of the Week 4 and Week 8 measurements of each of the Treatment Periods. The null hypotheses to be tested are that the mean change from study baseline in percent predicted FEV₁ to the average of the Week 4 and Week 8 measurements is the same for (i) VX-661/ivacaftor and placebo and (ii) ivacaftor monotherapy and placebo.

The primary efficacy analysis is based on a mixed effects model. This model will include the absolute change from study baseline in percent predicted FEV₁ to the average of the Week 4 and Week 8 measurements as the dependent variable, treatment and period as fixed effects, and subject as a random effect. The within-subject covariance will be assumed to have the same compound symmetry (CS) structure for sequences containing placebo treatment but will be different from the CS structure for sequences containing active treatment in both periods. Denominator degrees of freedom for the F-test for fixed effects will be estimated using the Kenward-Roger approximation.⁵¹ No imputation of missing data will be done. Subjects who have data only for one of the periods will have a structure similar to a parallel group trial. Assuming that the subjects have dropped out at random, an estimate of treatment effect will be based on such subjects and will then be combined with the estimate from subjects who have data in both Treatment Periods with weights based on the precision of these estimates.

The estimated mean of the dependent variable, a 95% confidence interval, and a 2-sided *P* value will be provided for each treatment. Similarly, the estimated between group treatment differences along with the corresponding 95% confidence interval and 2-sided *P* values will be presented. A sensitivity analysis based on a mixed effects model using absolute change from study baseline in percent predicted FEV₁ to the average of the Week 4 and Week 8 measurements of Treatment Period 1 will be performed to assess the treatment difference as compared to the primary efficacy analysis. The resulting model will include treatment as a fixed effect, study baseline as covariate and subject as a random effect. Additionally, a mixed model repeated measures (MMRM) will be used with period, visit, treatment, and treatment by visit as fixed effects and subject as a random effect. The change from study baseline will be the dependent variable. The repeated measures analysis will enable usage of all post-baseline available data and provide least squares mean estimates at each visit within a given treatment as well as estimates of treatment difference at each visit or across all visits.

12.3.3.2 Analysis of Secondary Efficacy Variables

For all secondary efficacy endpoints, the primary analysis will be based on change from study baseline.

Key Secondary Endpoint

- **Absolute change in the CFQ-R respiratory domain score from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period:**
Analysis of this variable will be similar to that of the primary analysis of the primary efficacy endpoint.

Secondary Endpoints

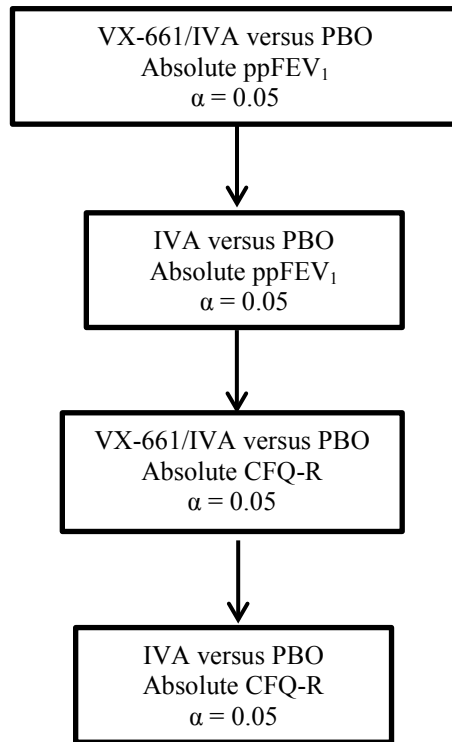
- **Relative change in percent predicted FEV₁ from study baseline to the average of the Week 4 and Week 8 measurements of each of the Treatment Periods:** Analysis of this variable will be similar to that of the primary analysis of the primary efficacy endpoint.
- **Absolute change in sweat chloride from study baseline to the average of the Week 4 and Week 8 measurements in each Treatment Period:** Analysis of this variable will be similar to that of the primary analysis of the primary efficacy endpoint.

Sensitivity analysis, supportive analysis, and subgroup analysis of secondary variables may be described in the SAP.

12.3.3.3 Adjustment for Multiple Comparisons

There are 3 potential treatment comparisons for the primary and key secondary endpoint: VX-661/ivacaftor versus placebo, ivacaftor monotherapy versus placebo, and VX-661/ivacaftor versus ivacaftor monotherapy. The testing strategy will be limited to the comparison of VX-661/ivacaftor versus placebo and ivacaftor monotherapy versus placebo. The testing procedure is summarized in [Figure 12-1](#).



Figure 12-1 Testing Strategy for the Primary and Key Secondary Endpoint

IVA: ivacaftor; PBO: placebo; ppFEV₁: percent predicted forced expiratory volume in 1 second;
CFQ-R: Cystic Fibrosis Questionnaire–Revised (respiratory domain)

A hierarchical testing strategy with $\alpha = 0.05$ will be used to strongly control the overall type I error rate at the 0.05 level. The testing hierarchy is as follows:

1. Absolute change in percent predicted FEV₁ from study baseline to the average of the Week 4 and Week 8 measurements for VX-661/ivacaftor versus placebo.
2. Absolute change in percent predicted FEV₁ from study baseline to the average of the Week 4 and Week 8 measurements for ivacaftor monotherapy versus placebo.
3. Absolute change in CFQ-R respiratory domain score from study baseline to the average of the Week 4 and Week 8 measurements for VX-661/ivacaftor versus placebo.
4. Absolute change in CFQ-R respiratory domain score from study baseline to the average of the Week 4 and Week 8 measurements for ivacaftor monotherapy versus placebo.

Note that comparisons of VX-661/ivacaftor versus ivacaftor will be performed and the *P*-values will be reported, but the tests will be performed without strong Type I error control.

12.3.4 Safety Analysis

All safety analyses will be based on the set of data associated with the TE period for Treatment Period 1 and the TE period for Treatment Period 2. Safety analyses will use the Safety Set. The summaries will be by treatment received.

For safety analysis, the period baseline will be used.

All safety data will be presented in individual subject data listings.

The overall safety profile of study drug will be assessed in terms of the following safety and tolerability endpoints:

- Incidence of treatment-emergent adverse events (TEAEs)
- Clinical laboratory values (i.e., hematology, serum chemistry, lipid panel, vitamin levels, urinalysis, and coagulation studies)
- ECGs
- Vital signs
- Pulse oximetry
- Spirometry

12.3.4.1 Adverse Events

For analysis purposes, AEs will be classified as pretreatment AEs, TEAEs, or post-treatment AEs, defined as follows:

- **Pretreatment AE:** any AE that started before the first dose of study drug.
- **TEAE:** any AE that increased in severity or that was newly developed during the TE period for Treatment Period 1 or Treatment Period 2. An AE that started (or increased in severity) during a specific Treatment Period will be attributed to the treatment the subject was receiving during the Treatment Period.
- **Post-treatment AE:** any AE that increased in severity or that was newly developed beyond the TE period for Treatment Period 2, or between the TE periods for Treatment Period 1 and Treatment Period 2, or beyond the TE period for Treatment Period 1 for subjects who do not have Treatment Period 2.

For AEs with missing or partial start date, if there is no clear evidence that the AEs started (or increased in severity) before the first dose, the start date will be imputed to the first dosing date and the AE assigned to the treatment in Treatment Period 1.

AE summary tables will be presented for TEAE only and will include the following:

- All TEAEs
- TEAEs by relationship
- TEAEs by maximal severity
- TEAEs leading to treatment discontinuation

- Serious TEAEs
- TEAEs leading to death
- Frequently reported TEAEs

Summaries will be presented by MedDRA system organ class and preferred term using frequency counts and percentages (i.e., number and percentage of subjects with an event). When summarizing the number and percentage of subjects with an event, subjects with multiple occurrences of the same AE or a continuing AE will be counted once, only the maximum severity level will be presented in the severity summaries, and the worst/highest relationship level in the relationship summaries. An AE overview table will be provided. In addition, a listing containing individual subject AE data for all deaths and other serious and significant AEs will be provided separately. All AEs, including pre- and post-treatment AEs, will be presented in individual subject data listings.

12.3.4.2 Clinical Laboratory Assessments

The raw values and change from period baseline values of the continuous laboratory parameters will be summarized in SI units by treatment group at each scheduled time point during the TE period. In addition, the mean value at each visit will be plotted by treatment groups for each of the liver function parameters.

The number and percentage of subjects with at least 1 potentially clinically significant (PCS) event during the TE period will be summarized by treatment group. The PCS (post-baseline) shift from period baseline will also be summarized by treatment group for selected laboratory parameters. The PCS criteria and the parameter selection criteria will be provided in the SAP.

Results of urinalysis and serum pregnancy test will be listed in individual subject data listings only. In addition, a listing containing individual subject laboratory measurements outside the reference ranges will be provided. This listing will include data from scheduled and unscheduled time points.

12.3.4.3 Electrocardiogram

A summary of raw values and change from period baseline values will be provided by treatment group at each scheduled time point during the TE period for the following standard digital ECG measurements: PR, QT, and QTc for HR interval (QTcF); QRS duration; and HR. In addition, the mean value at each visit will be plotted by treatment groups for QTcF.

The number and percentage of subjects with at least 1 PCS event during the TE period will be tabulated by treatment group. The PCS criteria for ECG data will be provided in the SAP.

Additional ECG analyses will be described in the SAP.



12.3.4.4 Vital Signs

The raw values and change from period baseline values during the TE period will be summarized by treatment group at each scheduled time point: systolic and diastolic blood pressure (mm Hg), body temperature (°C), HR (beats per minute [bpm]), and respiratory rate (breaths per minute).

The number and percentage of subjects with at least 1 PCS event during the TE period will be tabulated by treatment group. The PCS criteria for vital signs data will be provided in the SAP.

Additional vital sign analyses will be described in the SAP.

12.3.4.5 Physical Examination

PE findings will be presented as a data listing only. Clinically relevant results identified after screening will be reported as AEs.

12.3.4.6 Other Safety Analysis

12.3.4.6.1 Pulse Oximetry

A summary of raw values and change from period baseline values during the TE period will be provided by treatment groups at each scheduled time point for the percent of oxygen saturation by pulse oximetry. In addition, the mean value at each visit will be plotted by treatment group for the percent of oxygen saturation.

The number and percentage of subjects with shift changes from period baseline (normal/missing and low according to the reference range) to the lowest percent of oxygen saturation during the TE period will be tabulated by treatment group.

12.3.4.6.2 Postdose Spirometry

For the 2-hour and 4-hour postdose measurements on Day 1 of each Treatment Period (Week 1 and Week 17), and at Day 15 of each Treatment Period (Week 2 and Week 18), a summary of raw values for percent predicted FEV₁ will be provided by treatment at each time point. The absolute change from the predose value of percent predicted FEV₁ on the same day will be summarized by treatment at each time point. In addition, a boxplot by time point will be provided. Within each treatment, Day 1 and Day 15 values will be presented on the same plot.

The above analyses will be repeated for FEV₁.

In addition, the number and percentage of subjects with percent predicted FEV₁ decline ≥ 10 , ≥ 15 , and ≥ 20 percentage points in the absolute change from the predose value will be summarized by treatment and by assessment day and time.

12.3.5 Interim and IDMC Analyses

12.3.5.1 Interim Analysis

No interim analyses of efficacy are planned.



12.3.5.2 IDMC Analysis

An IDMC will be formed before study initiation. The IDMC's objectives and operational details will be defined in a separate document (IDMC Charter), which will be finalized before the first subject is screened. The IDMC will conduct regular planned safety reviews of study data as outlined in the IDMC Charter.

12.4 Clinical Pharmacology Analysis

A detailed description of the clinical pharmacology analyses will be provided in a CPAP. Listings of plasma concentration data of VX-661, ivacaftor, and their metabolites will be provided in the clinical study report. A population approach will be used to analyze the time-versus-plasma concentration data of VX-661, ivacaftor, and their metabolites. The PK/PD relationship between concentrations of VX-661 and ivacaftor and (their metabolites as appropriate) and efficacy and safety measurements may be investigated. The results of the PK and PK/PD analyses using a population approach will be presented in a separate report.

13 PROCEDURAL, ETHICAL, REGULATORY, AND ADMINISTRATIVE CONSIDERATIONS

13.1 Adverse Event and Serious Adverse Event Documentation, Severity Grading, and Reporting

13.1.1 Adverse Events

13.1.1.1 Definition of an Adverse Event

An AE is defined as any untoward medical occurrence in a subject during the study; the event does not necessarily have a causal relationship with the treatment. This includes any newly occurring event or worsening of a preexisting condition (e.g., increase in its severity or frequency) after the ICF is signed.

An AE is considered serious if it meets the definition in [Section 13.1.2.1](#).

13.1.1.2 Clinically Significant Assessments

Study assessments, including laboratory tests, ECGs, PEs, and vital signs, will be assessed, and those deemed a clinically significant worsening from baseline documented as an AE. When possible, a clinical diagnosis for the study assessment will be provided rather than the abnormal test result alone (e.g., urinary tract infection, anemia). In the absence of a diagnosis, the abnormal study assessment itself will be listed as the AE (e.g., bacteria in urine or decreased hemoglobin).

An abnormal study assessment is considered clinically significant if the subject has 1 or more of the following:

- Concomitant signs or symptoms related to the abnormal study assessment
- Further diagnostic testing or medical/surgical intervention
- A change in the dose of study drug or discontinuation from the study

Repeat testing to determine whether the result is abnormal, in the absence of any of the above criteria, does not necessarily meet clinically significant criteria. The determination of whether the study assessment results are clinically significant will be made by the investigator.

A laboratory value that is Grade 4 will not automatically be an SAE. A Grade 4 laboratory value will be an SAE if the clinical status of the subject indicates a life-threatening AE.

13.1.1.3 Documentation of Adverse Events

All AEs will be collected from the time ICF is signed until the following time points:

- For subjects who do not enroll: until time of screen failure (e.g., screen failure, withdrawal of consent)
- For enrolled subjects who have a Safety Follow-up Visit: through the Safety Follow-up Visit
- For enrolled subjects who do not have a Safety Follow-up Visit, through the **earliest** of
 - 28 days after the last dose of study drug
 - The ETT Visit, if that visit is 3 weeks or later following the last dose of study drug ([Section 8.1.6](#))
 - prior to the first dose of study drug in the extension study.

All subjects will be queried, using non-leading questions, about the occurrence of AEs at each study visit. When possible, a constellation of signs and/or symptoms will be identified as 1 overall event or diagnosis. All AEs for enrolled subjects will be recorded in the eCRF and source document. AEs for subjects who are screened but not subsequently enrolled in the study will be recorded only in the subject's source documents. The following data will be documented for each AE:

- Description of the event
- Classification of “serious” or “nonserious”
- Date of first occurrence and date of resolution (if applicable)
- Severity
- Causal relationship to study drug(s)
- Action taken
- Outcome
- Concomitant medication or other treatment given
- Indication of dose limiting toxicity

13.1.1.4 Adverse Event Severity

The investigator will determine and record the severity of all serious and non-serious AEs. The guidance available at the following website will be consulted: Common Terminology



Criteria for Adverse Events (CTCAE), Version 4.0, Cancer Therapy Evaluation Program, http://ctep.cancer.gov/protocolDevelopment/electronic_applications/ctc.htm (accessed August 2012). AEs of CTCAE Grades 4 and 5 will be documented as “life-threatening.” In considering the severity of an AE in a pediatric subject, the investigator will consider that reference ranges for pediatric clinical laboratory parameters may differ from those given in the CTCAE. The severity of an AE that does not appear in the CTCAE will be determined according to the definitions in Table 13-1.

Table 13-1 Grading of AE Severity

Classification	Definition
Mild (Grade 1)	Mild level of discomfort and does not interfere with regular activities
Moderate (Grade 2)	Moderate level of discomfort and significantly interferes with regular activities
Severe (Grade 3)	Significant level of discomfort and prevents regular activities
Life-threatening (Grade 4)	Any adverse drug experience that places the subject, in the view of the investigator, at immediate risk of death

13.1.1.5 Adverse Event Causality

Every effort will be made by the investigator to assess the relationship of the AE, if any, to the study drug(s). Causality will be classified using the categories presented in Table 13-2.

Table 13-2 Classifications for AE Causality

Classification	Definition
Related	There is an association between the event and the administration of investigational study drug, a plausible mechanism for the event to be related to the investigational study drug and causes other than the investigational study drug have been ruled out, and/or the event re-appeared on re-exposure to the investigational study drug.
Possibly related	There is an association between the event and the administration of the investigational study drug and there is a plausible mechanism for the event to be related to investigational study drug, but there may also be alternative etiology, such as characteristics of the subject’s clinical status or underlying disease.
Unlikely related	The event is unlikely to be related to the investigational study drug and likely to be related to factors other than investigational study drug.
Not related	The event is related to an etiology other than the investigational study drug (the alternative etiology will be documented in the study subject's medical record).

AE: adverse event.

13.1.1.6 Study Drug Action Taken

The investigator will classify the study drug action taken with regard to the AE. The action taken will be classified according to the categories shown in Table 13-3.

Table 13-3 Classifications for Study Drug Action Taken With Regard to an AE

Classification	Definition
Dose not changed	Study drug dose not changed in response to an AE.
Dose reduced	Not applicable for this study
Drug interrupted	Study drug administration interrupted in response to an AE.
Drug withdrawn	Study drug administration permanently discontinued in response to an AE.
Not applicable	Action taken regarding study drug administration does not apply. "Not applicable" will be used in circumstances such as when the investigational treatment had been completed before the AE began and no opportunity to decide whether to continue, interrupt, or withdraw treatment is possible.

AE: adverse event.

13.1.1.7 Adverse Event Outcome

An AE will be followed until the investigator has determined and provided the final outcome. The outcome will be classified according to the categories shown in Table 13-4.

Table 13-4 Classifications for Outcome of an AE

Classification	Definition
Recovered/Resolved	Resolution of an AE with no residual signs or symptoms
Recovered/ Resolved With Sequelae	Resolution of an AE with residual signs or symptoms
Not Recovered/Not Resolved (Continuing)	Either incomplete improvement or no improvement of an AE, such that it remains ongoing
Fatal	Outcome of an AE is death. "Fatal" will be used when death is at least possibly related to the AE.
Unknown	Outcome of an AE is not known (e.g., a subject lost to follow-up)

AE: adverse event.

13.1.1.8 Treatment Given

The investigator ensures adequate medical care is provided to subjects for any AEs, including clinically significant laboratory values related to study drug. In addition, the investigator will describe whether any treatment was given for the AE. "Yes" is used if any treatment was given in response to an AE, and may include treatments such as other medications, hospitalization, surgery, or physical therapy. "No" indicates the absence of any kind of treatment for an AE.

13.1.2 Serious Adverse Events

13.1.2.1 Definition of a Serious Adverse Event

An SAE is any AE that meets any of the following outcomes:

- Fatal (death, regardless of cause, that occurs during participation in the study or occurs after participation in the study and is suspected of being a delayed toxicity due to administration of the study drug)
- Life-threatening, such that the subject was at immediate risk of death from the reaction as it occurred
- Inpatient hospitalization or prolongation of hospitalization
- Persistent or significant disability/incapacity (disability is defined as a substantial disruption of a person's ability to conduct normal life functions)
- Congenital anomaly or birth defect
- Important medical event that, based upon appropriate medical judgment, may jeopardize the subject or may require medical or surgical intervention to prevent 1 of the outcomes listed above (e.g., an allergic bronchospasm requiring intensive treatment in an emergency room or at home)

If a subject has a hospitalization or procedure (e.g., surgery) for an event or condition that occurred before the subject signed the ICF, and the hospitalization or procedure was planned before the subject signed the ICF, the hospitalization or procedure should not be considered to indicate an SAE, unless an AE caused the hospitalization or procedure to be rescheduled sooner or to be prolonged relative to what was planned. In addition, hospitalizations clearly not associated with an AE (e.g., social hospitalization for purposes of respite care) should not be considered to indicate an SAE.

Clarification will be made between the terms “serious” and “severe,” because they are not synonymous. The term “severe” is often used to describe the intensity (severity) of a specific event, as in mild, moderate, or severe myocardial infarction. The event itself, however, may be of relatively minor medical significance, such as a severe headache. This is not the same as “serious,” which is based on subject/event outcome or action described above, and is usually associated with events that pose a threat to a subject's life or functioning. Seriousness, not severity, serves as a guide for defining expedited regulatory reporting obligations.

13.1.2.2 Documentation of Serious Adverse Events

All SAEs that occur after obtaining informed consent and assent (where applicable) through the Safety Follow-up Visit, regardless of causality, will be reported by the investigator to Vertex GPS. In addition, all SAEs that occur after the Safety Follow-up Visit and are considered related to study drug(s) will be reported to Vertex GPS **within 24 hours**.

SAEs will be recorded on the Vertex Organized Safety Information Collection Form (hereafter referred to as the “SAE Form”) using a recognized medical term or diagnosis that accurately reflects the event. SAEs will be assessed by the investigator for relationship to the

investigational study drug(s) and possible etiologies. On the Clinical Trials SAE Form, relationship to study drug(s) will be assessed only as related (includes possibly related) or not related (includes unlikely related), and severity assessment will not be required. For the purposes of study analysis, if the event has not resolved at the end of the study reporting period, it will be documented as ongoing. For purposes of regulatory safety monitoring, the investigator is required to follow the event to resolution and report to Vertex the outcome of the event using the Vertex Clinical Trials SAE Form.

13.1.2.3 Reporting Serious Adverse Events

The investigator is responsible for notifying the sponsor within 24 hours of identifying an SAE, regardless of the presumed relationship to the investigational study drug. The Vertex Clinical Trial SAE Form will be completed for new/initial events as well as to report follow-up information on previously reported events. Investigators are asked to report follow-up information as soon as it becomes available to ensure timely reporting to health authorities.

Please send completed SAE Forms to Vertex GPS via
Email: [REDACTED] (Preferred Choice)
Or via Fax: [REDACTED]
Contact Telephone: [REDACTED]

13.1.2.4 Expedited Reporting and Investigator Safety Letters

Vertex, as study sponsor, is responsible for reporting suspected, unexpected, serious adverse reactions (SUSARs) involving the study drug(s) to all regulatory authorities and participating investigators in accordance with ICH Guidelines and/or local regulatory requirements, as applicable. In addition, Vertex, or authorized designee, will be responsible for the submission of safety letters to central independent ethics committees (IECs).

It is the responsibility of the investigator or designee to promptly notify the local IRB/local IEC of all unexpected serious adverse drug reactions involving risk to human subjects.

13.2 Administrative Requirements

13.2.1 Ethical Considerations

The study will be conducted in accordance with the current ICH GCP Guidelines, which are consistent with the ethical principles founded in the Declaration of Helsinki, and in accordance with local applicable laws and regulations. The IRB/IEC will review all appropriate study documentation to safeguard the rights, safety, and well-being of the subjects. The study will only be conducted at sites where IRB/IEC approval has been obtained. The protocol, Investigator's Brochure, sample ICF, advertisements (if applicable), written information given to the subjects (including diary cards), safety updates, annual progress reports, and any revisions to these documents will be provided to the IRB/IEC by the investigator or Vertex, as allowable by local applicable laws and regulations.

13.2.2 Subject Information and Informed Consent and Assent

After the study has been fully explained, written informed consent will be obtained from the subject or legal representative or guardian (if applicable), and assent will be obtained from



the subject (if applicable), before study participation. The method of obtaining and documenting the informed consent and assent (if applicable) and the contents of the consent will comply with ICH GCP and all applicable laws and regulations and will be subject to approval by Vertex or its designee.

13.2.3 Investigator Compliance

No modifications to the protocol will be made without the approval of both the investigator and Vertex. Changes that significantly affect the safety of the subjects, the scope of the investigation, or the scientific quality of the study (i.e., efficacy assessments) will require IRB/IEC notification before implementation, except where the modification is necessary to eliminate an apparent immediate hazard to human subjects. Vertex will submit all protocol modifications to the required regulatory authorities.

When circumstances require an immediate departure from procedures set forth in the protocol, the investigator will contact Vertex to discuss the planned course of action. If possible, contact will be made before the implementation of any changes. Any departures from protocol will be fully documented in the source documentation and in a protocol deviation log.

13.2.4 Access to Records

The investigator will make the office and/or hospital records of subjects enrolled in this study available for inspection by Vertex or its representative at the time of each monitoring visit and for audits. The records will also be available for direct inspection, verification, and copying, as required by applicable laws and regulations, by officials of the regulatory health authorities (FDA and others). The investigator will comply with applicable privacy and security laws for use and disclosure of information related to the research set forth in this protocol.

13.2.5 Subject Privacy

To maintain subject confidentiality, all eCRFs, study reports, and communications relating to the study will identify subjects by assigned subject numbers. As required by federal regulations, the investigator will allow Vertex and/or its representatives access to all pertinent medical records to allow for the verification of data gathered in the eCRFs/SAE Forms and the review of the data collection process. The FDA (or other regulatory authority) may also request access to all study records, including source documentation, for inspection.

As applicable, in accordance with the Health Insurance Portability and Accountability Act and associated privacy regulations, a subject authorization to use personally identifiable health information may be required from each subject before research activities begin. This authorization document will clearly specify which parties will have access to a subject's personal health information, for what purpose, and for how long.

13.2.6 Record Retention

The investigator will maintain all study records according to ICH GCP guidelines and/or applicable local regulatory requirement(s), whichever is longest, as described in the Clinical Trial Agreement. If the investigator withdraws from the responsibility of keeping the study



records, custody will be transferred to a person willing to accept the responsibility, and Vertex will be notified.

13.2.7 Study Termination

At any time, Vertex may terminate this study in its entirety or may terminate this study at any particular site. In addition, for reasonable cause, either the investigators or their IRBs/IECs may terminate the study at their center.

Conditions that may lead to reasonable cause and warrant termination include, but are not limited to:

- Subject or investigator noncompliance
- Unsatisfactory subject enrollment
- Lack of adherence to protocol procedures
- Lack of evaluable and/or complete data
- Potentially unacceptable risk to study subjects
- Decision to modify drug development plan
- Decision by the FDA or other regulatory authority

Written notification that includes the reason for the clinical study termination is required.

13.3 Data Quality Assurance

Vertex or its designated representative will conduct a study site visit to verify the qualifications of each investigator, inspect clinical study site facilities, and inform the investigator of responsibilities and procedures for ensuring adequate and correct study documentation.

The investigator is required to prepare and maintain adequate and accurate case histories designed to record all observations and other data pertinent to the study for each study participant. Study data for each enrolled subject will be entered into an eCRF by study site personnel using a secure, validated web-based electronic data capture (EDC) application. Vertex will have read-only access to site-entered clinical data in the EDC application.

Instances of missing, discrepant, or uninterpretable data will be queried with the investigator for resolution. Any changes to study data will be made to the eCRF and documented in an audit trail, which will be maintained within the clinical database.

13.4 Monitoring

Monitoring and auditing procedures developed or approved by Vertex will be followed to comply with GCP guidelines. On-site checking of the eCRFs/SAE Forms for completeness and clarity, cross-checking with source documents, and clarification of administrative matters will be performed.

The study will be monitored by Vertex or its designee. Monitoring will be done by personal visits from a representative of Vertex, or designee (study site monitor), who will review the



eCRFs/SAE Forms and source documents. The study site monitor will ensure that the investigation is conducted according to the protocol design and regulatory requirements.

13.5 Electronic Data Capture

Vertex will provide the study sites with secure access to and training on the EDC application sufficient to permit study site personnel to enter or correct information in the eCRFs on the subjects for which they are responsible.

An eCRF will be completed for each enrolled study subject. It is the investigator's responsibility to ensure the accuracy, completeness, clarity, and timeliness of the data reported in the subject's eCRF. Source documentation supporting the eCRF data will indicate the subject's participation in the study and will document the dates and details of study procedures, AEs, other observations, and subject status.

The investigator, or designated representative, will complete the eCRF as soon as possible after information is collected.

The audit trail entry will show the user's identification information and the date and time of any correction. The investigator must provide formal approval of all the information in the eCRFs, including any changes made to the eCRFs, to endorse the final submitted data for the subjects for whom the investigator is responsible.

Vertex will retain the eCRF data and corresponding audit trails. A copy of the final archival eCRF in the form of a compact disc or other electronic media will be placed in the investigator's study file.

[REDACTED]

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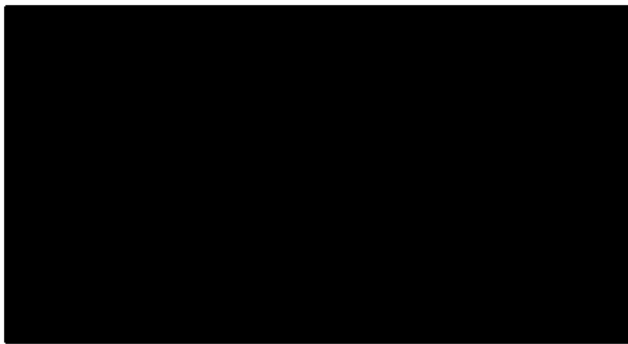
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15 PROTOCOL SIGNATURE PAGES

15.1 Sponsor Signature Page

Protocol #:	VX14-661-108	Version #:	3.0	Version Date	10 June 2016
Study Title: A Phase 3, Randomized, Double-Blind, Placebo-Controlled, Crossover Study to Evaluate the Efficacy and Safety of Ivacaftor and VX-661 in Combination With Ivacaftor in Subjects Aged 12 Years and Older With Cystic Fibrosis, Heterozygous for the <i>F508delCFTR</i> Mutation, and a Second Allele With a <i>CFTR</i> Mutation Predicted to Have Residual Function					

This Clinical Trial Protocol has been reviewed and approved by the sponsor.



VX14-661-108 Medical Monitor

Title

14 JUNE 2016

Date



15.2 Investigator Signature Page

Protocol #:	VX14-661-108	Version #:	3.0	Version Date	10 June 2016
Study Title: A Phase 3, Randomized, Double-Blind, Placebo-Controlled, Crossover Study to Evaluate the Efficacy and Safety of Ivacaftor and VX-661 in Combination With Ivacaftor in Subjects Aged 12 Years and Older With Cystic Fibrosis, Heterozygous for the <i>F508delCFTR</i> Mutation, and a Second Allele With a <i>CFTR</i> Mutation Predicted to Have Residual Function					

I have read Protocol VX14-661-108, Version 3.0 and agree to conduct the study according to its terms. I understand that all information concerning VX-661 and ivacaftor and this protocol supplied to me by Vertex Pharmaceuticals Incorporated (Vertex) is confidential.

Printed Name

Signature

Date



16 APPENDIX A: SECOND *CFTR* ALLELE MUTATIONS INCLUDED FOR SUBJECTS WHO ARE HETEROZYGOUS FOR THE *F508del-CFTR* MUTATION

Per the study eligibility criteria, heterozygous *F508del-CFTR* subjects must have a second *CFTR* allele that encodes a mutation predicted to have residual function. Criteria for including a mutation are (1) having residual function based on population-level phenotypic data and (2) in vitro responsiveness to ivacaftor. The criteria for clinical phenotype are average sweat chloride <86 mmol/L (1 standard deviation from the average sweat chloride for the most common processing and trafficking mutation, *F508del-CFTR*), and incidence of pancreatic insufficiency ≤50% based on subjects with at least 1 copy of the mutation from epidemiologic data¹⁶ or published literature.¹⁷⁻²⁴ In vitro response to ivacaftor was defined as an increase in percent normal chloride transport of ≥10 percentage points in transfected Fischer Rat Thyroid (FRT) cells expressing the *CFTR* form produced by the mutation. The list below represents eligible mutations.

***CFTR* Mutations Predicted to Have Residual Function and That May Be Responsive to Ivacaftor**

2789+5G→A	R74W	R352Q	R1070W
3849+10kbC→T	D110E	A455E	F1074L
3272-26A→G	D110H	D579G	D1152H
711+3A→G	R117C	S945L	D1270N
E56K	E193K	S977F	
P67L	L206W	F1052V	
E831X	R347H	K1060T	