2018 PATIENT REGISTRY ANNUAL DATA REPORT

CYSTIC FIBROSIS FOUNDATION®
MISSION OF THE CYSTIC FIBROSIS FOUNDATION

The mission of the Cystic Fibrosis Foundation is to cure cystic fibrosis and to provide all people with the disease the opportunity to lead full, productive lives by funding research and drug development, promoting individualized treatment, and ensuring access to high-quality, specialized care.

SOURCE OF DATA

Cystic fibrosis patients under care at CF Foundation-accredited care centers in the United States, who consented to have their data entered.

SUGGESTED CITATION

Cystic Fibrosis Foundation Patient Registry
2018 Annual Data Report
Bethesda, Maryland
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FIGURE PERMISSIONS

To request use of charts and data provided in this report, contact the CF Foundation Patient Registry team by email at reghelp@cff.org.

PHOTOGRAPHY BY

Cade Martin

SPECIAL ACKNOWLEDGMENTS

Those who contributed to the maintenance of PortCF, analysis of data, and creation of this report:

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August 2019

Dear Friends and Colleagues:

I am really pleased to share the 2018 Patient Registry Annual Data Report with you. The Cystic Fibrosis Foundation Patient Registry remains a very important resource to the CF community, contributing to clinical trial design, quality improvement, screening for clinical trial eligibility, and “real world” research.

Many thanks to each and every one of you who contribute to the success of the Registry — most importantly, people with CF and their families who generously agree to share their data and the Registry coordinators and care team members who collect and enter the data. We hope that you feel a sense of pride as you read through this report. It would not be possible without your vital contributions.

The Registry team always searches for new and better ways to display the data and this year’s report is no exception. For example, the graphic on page 57 shows the proportion of patients eligible for a CFTR modulator and those prescribed these therapies from 2011 to 2018. Note the interesting changes that occurred following FDA approval of tezacaftor/ivacaftor in February 2018. Also of note, we’ve added new information in the transplant section of the report. With a renewed focus on advanced lung disease and lung transplantation, we look forward to providing more information on this important segment of the population in future reports.

This is a truly exciting time in CF, with advances in health care delivery and new therapeutics with transformative potential. Together, we will continue to track these and other important developments in the Registry.

Thank you all for your hard work throughout the year and your commitment to the CF Foundation’s mission.

Bruce C. Marshall, M.D.
Senior Vice President of Clinical Affairs
Cystic Fibrosis Foundation
# TABLE OF CONTENTS

## ABOUT THIS REPORT

## DEMOGRAPHICS
- Characteristics of Adults with CF
  - Health Insurance Information

## DIAGNOSIS
- Diagnostic Characteristics of Individuals with CF
- Diagnostic Tests

## CFTR GENE MUTATIONS

## GUIDELINES: CARE, SCREENING, AND PREVENTION
- Patient Care Guidelines
- Infant Care Guidelines

## MICROBIOLOGY
- *Pseudomonas aeruginosa*
- *Staphylococcus aureus*
- Nontuberculous Mycobacteria

## NUTRITION
- Infant Feeding

## PULMONARY AND NUTRITIONAL OUTCOMES

## PULMONARY FUNCTION
- Pulmonary Exacerbations

## THERAPIES
- Gastrointestinal (GI) Therapies
- Pulmonary Therapies
- CFTR Modulator Therapies

## COMPLICATIONS
- Cystic Fibrosis-Related Diabetes (CFRD)
- Depression and Anxiety

## TRANSPLANTATION
- Lung Transplantation
SURVIVAL 72
  Median Predicted Survival 72
  Median Conditional Predicted Survival 73
  Mortality Rate 73
  Median Age at Death 74
  Causes of Death 74

CF FOUNDATION PATIENT REGISTRY QUESTIONNAIRE 75

REFERENCES 85
ABOUT THIS REPORT

The Annual Data Report is based on data entered in the CF Foundation Patient Registry through our online portal, PortCF®. Data is entered by teams of dedicated health professionals in our nationwide network of more than 120 CF Foundation-accredited care centers.

Inclusion Criteria

This Annual Data Report contains data from individuals diagnosed with CF who (a) have consented to participate in the Registry, and (b) were seen in a CF care center during the 2018 calendar year, including those who were born, diagnosed, or died in the year.

Data from individuals who have received a lung transplant are only included in the chapters on Demographics, Diagnosis, CFTR Gene Mutations, Transplantation, and Survival.

The included populations represented in the figures vary and are based on the eligibility criteria described in the title and/or footnotes. Figures titled in gray reflect patient-level data that include individuals who are post-transplant. Figures titled in purple reflect patient-level data that do NOT include individuals who are post-transplant. Figures titled in blue present data on center-level variation and include only those centers with 10 or more eligible individuals. Exceptions to this are figures showing center-level variation for infants, people with a G551D mutation, people with cystic fibrosis-related diabetes (CFRD), and people who had a pulmonary exacerbation. For these figures, centers with five or more eligible individuals are included.

Exclusion Criteria

Data from individuals with a diagnosis of CFSPID/CRMS (CF screen positive, inconclusive diagnosis/CFTR-related metabolic syndrome) or CFTR-related disorder are excluded from all figures except for the one on new diagnoses in the reporting year.

Data from individuals who have received a lung transplant are excluded from any chapters not specified above in the inclusion criteria. In the past, data from individuals who received a lung transplant were included in many of the figures. This impacted reporting of prevalent complications in the post-transplant population, such as CFRD and osteoporosis. This year, exclusion of data from individuals who received a lung transplant has resulted in a lower prevalence of these complications as compared to previous years.

More information about data included in the Annual Data Report and interpretation of the tables and figures can be found in the online Technical Supplement on cff.org.
## Summary of the Cystic Fibrosis Foundation Patient Registry, 2003–2018

### Demographics

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>People with CF (n)</td>
<td>21,421</td>
<td>25,286</td>
<td>28,030</td>
<td>30,139</td>
<td>30,775</td>
</tr>
<tr>
<td>Newly diagnosed individuals (n)</td>
<td>1,027</td>
<td>1,140</td>
<td>1,048</td>
<td>990</td>
<td>852</td>
</tr>
<tr>
<td>Detected by newborn screening (%)</td>
<td>11.9</td>
<td>43.0</td>
<td>60.0</td>
<td>56.7</td>
<td>61.5</td>
</tr>
<tr>
<td>Individuals with first CF event in less than 60 days after birth (%)</td>
<td>32.9</td>
<td>55.7</td>
<td>69.6</td>
<td>66.1</td>
<td>70.8</td>
</tr>
<tr>
<td>Mean age at diagnosis for all people with CF (years)</td>
<td>3.2</td>
<td>3.6</td>
<td>3.8</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Median age at diagnosis for all people with CF (months)</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>17.2</td>
<td>18.9</td>
<td>20.2</td>
<td>21.7</td>
<td>22.2</td>
</tr>
<tr>
<td>Median age (years)</td>
<td>15.1</td>
<td>16.9</td>
<td>17.9</td>
<td>19.3</td>
<td>19.8</td>
</tr>
<tr>
<td>Adults ≥18 years (%)</td>
<td>39.7</td>
<td>46.3</td>
<td>49.8</td>
<td>53.6</td>
<td>54.6</td>
</tr>
</tbody>
</table>

#### Race (not mutually exclusive)

<table>
<thead>
<tr>
<th>Race</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>White (%)</td>
<td>95.4</td>
<td>94.7</td>
<td>94.0</td>
<td>93.6</td>
<td>93.5</td>
</tr>
<tr>
<td>African American (%)</td>
<td>3.8</td>
<td>4.3</td>
<td>4.6</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>Other race (%)</td>
<td>1.8</td>
<td>2.4</td>
<td>3.1</td>
<td>3.6</td>
<td>3.7</td>
</tr>
<tr>
<td>Hispanic (any race) (%)</td>
<td>5.8</td>
<td>6.6</td>
<td>8.1</td>
<td>9.2</td>
<td>9.4</td>
</tr>
<tr>
<td>Males (%)</td>
<td>51.9</td>
<td>51.7</td>
<td>51.5</td>
<td>51.6</td>
<td>51.8</td>
</tr>
</tbody>
</table>

### Mortality

<table>
<thead>
<tr>
<th>Mortality</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total deaths (n)</td>
<td>356</td>
<td>434</td>
<td>421</td>
<td>386</td>
<td>410</td>
</tr>
<tr>
<td>Annual mortality rate (per 100) (%)</td>
<td>1.7</td>
<td>1.7</td>
<td>1.5</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Predicted median survival (five-year increments)</td>
<td>32.8</td>
<td>38.0</td>
<td>39.2</td>
<td>43.7</td>
<td>44.4</td>
</tr>
<tr>
<td>95% confidence interval (five-year increments)</td>
<td>32.1 - 33.7</td>
<td>36.7 - 38.8</td>
<td>38.0 - 40.9</td>
<td>42.2 - 44.9</td>
<td>43.4 - 45.9</td>
</tr>
<tr>
<td>Median age at death (years)</td>
<td>25.7</td>
<td>26.4</td>
<td>27.6</td>
<td>30.1</td>
<td>30.8</td>
</tr>
</tbody>
</table>

### Gi/Nutrition

<table>
<thead>
<tr>
<th>Body Mass Index (BMI) percentile in individuals 2 to 19 years (median)</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight &lt;10th CDC percentile (%)</td>
<td>21.0</td>
<td>16.4</td>
<td>13.1</td>
<td>10.5</td>
<td>10.3</td>
</tr>
<tr>
<td>Height &lt;5th CDC percentile (%)</td>
<td>14.9</td>
<td>12.8</td>
<td>10.8</td>
<td>9.7</td>
<td>9.5</td>
</tr>
<tr>
<td>BMI in individuals 20 to 40 years (median)</td>
<td>21.1</td>
<td>21.5</td>
<td>21.8</td>
<td>22.2</td>
<td>22.3</td>
</tr>
<tr>
<td>Pancreatic enzyme replacement therapy (%)</td>
<td>91.7</td>
<td>88.1</td>
<td>87.0</td>
<td>85.7</td>
<td>84.9</td>
</tr>
</tbody>
</table>

| Supplemental feeding - tube (%)                                       | 8.6   | 10.6  | 10.7   | 10.8     | 10.7     |
| Supplemental feeding - oral only (%)                                  | 34.8  | 38.5  | 42.1   | 44.5     | 43.9     |

### Pulmonary

<table>
<thead>
<tr>
<th>FVC % predicted (mean) (%)</th>
<th>83.5</th>
<th>86.4</th>
<th>87.2</th>
<th>88.5</th>
<th>89.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV, % predicted (mean) (%)</td>
<td>72.9</td>
<td>75.0</td>
<td>76.1</td>
<td>77.2</td>
<td>77.8</td>
</tr>
<tr>
<td>FEV/FVC ratio (mean) (%)</td>
<td>75.2</td>
<td>74.6</td>
<td>74.4</td>
<td>74.0</td>
<td>74.2</td>
</tr>
</tbody>
</table>

### Respiratory Microbiology

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pseudomonas aeruginosa</em> (P. aeruginosa or PA) (%)</td>
<td>57.5</td>
<td>52.9</td>
<td>48.8</td>
<td>45.7</td>
<td>44.4</td>
</tr>
<tr>
<td><em>Burkholderia cepacia</em> (B. cepacia) complex (%)</td>
<td>3.1</td>
<td>2.8</td>
<td>2.6</td>
<td>2.5</td>
<td>2.6</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (S. aureus) (%)</td>
<td>59.4</td>
<td>66.1</td>
<td>69.4</td>
<td>70.7</td>
<td>70.3</td>
</tr>
<tr>
<td>Methicillin-sensitive <em>Staphylococcus aureus</em> (MSSA) (%)</td>
<td>51.1</td>
<td>50.8</td>
<td>52.7</td>
<td>54.9</td>
<td>55.2</td>
</tr>
<tr>
<td>Methicillin-resistant <em>Staphylococcus aureus</em> (MRSA) (%)</td>
<td>12.0</td>
<td>22.7</td>
<td>26.2</td>
<td>25.9</td>
<td>25.0</td>
</tr>
<tr>
<td><em>Stenotrophomonas maltophilia</em> (S. maltophilia) (%)</td>
<td>11.2</td>
<td>12.7</td>
<td>14.2</td>
<td>12.9</td>
<td>12.3</td>
</tr>
<tr>
<td>Mycobacterial species (%)</td>
<td>-</td>
<td>-</td>
<td>12.1</td>
<td>12.7</td>
<td>13.6</td>
</tr>
</tbody>
</table>

Table continues on the next page
## Summary of the Cystic Fibrosis Foundation Patient Registry, 2003-2018 continued

<table>
<thead>
<tr>
<th>Health Care Utilization and Pulmonary Exacerbations (PEX)(^a)</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outpatient visits to CF centers reported per year (mean)</td>
<td>4.1</td>
<td>4.3</td>
<td>4.7</td>
<td>4.4</td>
<td>4.3</td>
</tr>
<tr>
<td>Treated with IV antibiotics for a pulmonary exacerbation (%)</td>
<td>-</td>
<td>36.8</td>
<td>35.7</td>
<td>34.2</td>
<td>33.3</td>
</tr>
<tr>
<td>Number of pulmonary exacerbations per year (mean)(^b)</td>
<td>-</td>
<td>0.71</td>
<td>0.69</td>
<td>0.67</td>
<td>0.64</td>
</tr>
<tr>
<td>Number of days of treatment for all PEX per year (mean)(^c)</td>
<td>-</td>
<td>30.8</td>
<td>29.2</td>
<td>28.9</td>
<td>27.5</td>
</tr>
<tr>
<td>Number of days of home IV treatment for all PEX per year (mean)(^d)</td>
<td>-</td>
<td>13.7</td>
<td>11.9</td>
<td>10.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Number of days of hospitalization for all PEX per year (mean)(^e)</td>
<td>-</td>
<td>17.1</td>
<td>17.3</td>
<td>18.3</td>
<td>17.9</td>
</tr>
</tbody>
</table>

### Pulmonary Therapies\(^f\)

<table>
<thead>
<tr>
<th>Therapy</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dornase alfa (≥6 years) (%)</td>
<td>70.9</td>
<td>83.5</td>
<td>88.3</td>
<td>91.6</td>
<td>91.9</td>
</tr>
<tr>
<td>Inhaled tobramycin (PA+ and ≥6 years) (%)(^g)</td>
<td>67.3</td>
<td>70.0</td>
<td>66.5</td>
<td>70.4</td>
<td>70.2</td>
</tr>
<tr>
<td>Inhaled aztreonam (PA+ and ≥6 years) (%)</td>
<td>-</td>
<td>2.5</td>
<td>41.4</td>
<td>43.8</td>
<td>43.3</td>
</tr>
<tr>
<td>Azithromycin (PA+ and ≥6 years) (%)(^h)</td>
<td>40.1</td>
<td>65.6</td>
<td>68.9</td>
<td>64.8</td>
<td>64.2</td>
</tr>
<tr>
<td>Hypertonic saline (≥6 years) (%)</td>
<td>-</td>
<td>43.4</td>
<td>63.2</td>
<td>72.1</td>
<td>73.4</td>
</tr>
<tr>
<td>Ivacaftor (all eligible individuals in that year) (%)</td>
<td>-</td>
<td>-</td>
<td>89.9</td>
<td>59.0</td>
<td>66.4</td>
</tr>
<tr>
<td>Lumacaftor/ivacaftor (all eligible individuals in that year) (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>52.9</td>
<td>63.2</td>
</tr>
<tr>
<td>Tezacaftor/ivacaftor (all eligible individuals in that year) (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>44.8</td>
</tr>
<tr>
<td>Oxygen (%)(^i)</td>
<td>5.6</td>
<td>11.6</td>
<td>11.5</td>
<td>11.0</td>
<td>10.8</td>
</tr>
<tr>
<td>Non-invasive ventilation (%)</td>
<td>-</td>
<td>2.2</td>
<td>2.8</td>
<td>3.1</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Transplants\(^j\)

<table>
<thead>
<tr>
<th>Transplant</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung (all procedures) (n)</td>
<td>143</td>
<td>155</td>
<td>242</td>
<td>255</td>
<td>253</td>
</tr>
<tr>
<td>Liver (n)</td>
<td>11</td>
<td>7</td>
<td>12</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td>Kidney (n)</td>
<td>10</td>
<td>8</td>
<td>11</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>

### Lost to Follow Up\(^k\)

| Lost to follow up (per 100 people with CF) (%)\(^l\) | -    | 4.7  | 4.2  | 3.3  | 2.9  |

---

\(a\) Includes data from transplant recipients.

\(b\) We anticipate that additional 2018 diagnoses will be entered into the Registry in 2019.

\(c\) First CF event is defined as: (1) date of first sweat test, (2) first date of genotyping, or (3) date of first encounter at a CF program.

\(d\) Pulmonary function data throughout this report reflect the use of Global Lung Initiative (GLI) equations\(^1\).

\(e\) Includes PA and multidrug-resistant PA found in any culture during the year.

\(f\) Includes MSSA and MRSA and reflects the prevalence of S. aureus among individuals who had a bacterial culture during the year. The percentages for MSSA and MRSA individually are greater than the total S. aureus percentage because MSSA and MRSA are not mutually exclusive.

\(g\) Percentage of people with CF with one or more mycobacterial species isolated out of those who had a mycobacterial culture during the year.

\(h\) Defined as a period of treatment with IV antibiotics in the hospital and/or at home.

\(i\) Among those with one or more pulmonary exacerbations in the year.

\(j\) Percentage of people with CF on therapy at any clinical visit in the year. All individuals noted as intolerant or having an allergy to a specific therapy were excluded.

\(k\) Includes TOBI\(^*\), TOBI\(^{™}\) Podhaler\(^*\) and Bethkis\(^*\) in 2017 and 2018. In prior years, only TOBI\(^*\) was available.

\(l\) Individuals were considered eligible if they met the selection criteria used in the first U.S. azithromycin trial\(^2\).

\(m\) Includes continuous, nocturnal, or with exertion.

\(n\) Defined as individuals seen in the previous reporting year (2017) but not the current reporting year (2018), and not known to have died.
DEMOGRAPHICS

The Registry contains data on people with CF from 1986 to 2018. During that time, substantial changes in specialized CF care have led to improved survival. This section shows the current and longitudinal distribution of demographic characteristics of individuals with CF in the Registry.

In 2018, there were 30,775 individuals with CF in the Registry. The number of adults with CF continues to increase, while the number of children remains relatively stable. In 2018, adults were 54.6 percent of the CF population, compared with 29.4 percent in 1988.

Currently, 9.4 percent of the individuals in the Registry identify as Hispanic. There has been a steady increase over the past 15 years, reflecting national population trends. Hispanics with CF tend to be younger than the overall CF population, with a median age of 13.6 years.
The median age of people with CF currently in the Registry is 19.8 years. The age range is birth to 88.7 years. Despite gains in survival, the age distribution remains markedly skewed toward younger ages.
Characteristics of Adults with CF

As a growing number of individuals with CF enter adulthood, it is encouraging to note that many are pursuing higher education and employment, are in committed relationships, and are having children of their own. About two-thirds of adults with CF are either studying or working. However, these charts also highlight the approximately one-quarter of adults who report being disabled or unemployed.

**Socioeconomic Characteristics of Adults 18 Years and Older with CF, 2018**

- **Education**
  - College Graduate: 30.8%
  - Some College: 30.8%
  - High School Diploma: 24.1%
  - Master’s/Doctoral level degree: 6.8%
  - Less than High School: 7.4%

- **Marital Status**
  - Married/Living Together: 43.4%
  - Single: 50.8%
  - Separated/Divorced: 5.3%
  - Widowed: 0.4%

- **Employment**
  - Full-time: 39.7%
  - Part-time: 12.2%
  - Retired: 3.0%
  - Unemployed: 7.2%
  - Homemaker: 3.3%
  - Disabled: 17.3%
  - Student: 17.4%
Over the last twenty years, there has been almost a tripling of the number of people who are married or living together and nearly four times the number of people with a college degree.

The number of pregnancies among women with CF has increased steadily since the 1990s. Registry data show that 280 women with CF were pregnant in 2018. The overall pregnancy rate among women with CF has remained relatively constant, in contrast to the pregnancy rate in the general U.S. population, which has declined during this time.4

Number of Pregnancies in Women 14 to 45 Years with CF, 1998–2018

The number of pregnancies among women with CF has increased steadily since the 1990s. Registry data show that 280 women with CF were pregnant in 2018. The overall pregnancy rate among women with CF has remained relatively constant, in contrast to the pregnancy rate in the general U.S. population, which has declined during this time.4
Health Insurance Information

Access to insurance coverage for specialized care and treatments is a challenge for some individuals with CF. Across all age groups, about half of the individuals in the Registry receive at least some component of their health insurance through federal or state-funded programs. Registry data show that in 2018, a majority of individuals with CF who were aged 18 to 25 were covered under their parents’ health insurance plan.

<table>
<thead>
<tr>
<th>Insurance Coverage in 2018</th>
<th>Age &lt; 18 (%)</th>
<th>Age 18 - 25 (%)</th>
<th>Age &gt; 26 (%)</th>
<th>All (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Individuals (n)</td>
<td>13,815</td>
<td>5,823</td>
<td>10,692</td>
<td>30,330</td>
</tr>
<tr>
<td>Health insurance policy (e.g., private insurance)</td>
<td>51.4</td>
<td>64.5</td>
<td>65.3</td>
<td>58.8</td>
</tr>
<tr>
<td>Medicare/Indian Health Services</td>
<td>0.5</td>
<td>5.3</td>
<td>25.0</td>
<td>10.1</td>
</tr>
<tr>
<td>Medicaid/state programs</td>
<td>54.8</td>
<td>43.0</td>
<td>27.3</td>
<td>42.9</td>
</tr>
<tr>
<td>TriCare or other military health plan</td>
<td>3.5</td>
<td>2.2</td>
<td>1.8</td>
<td>2.7</td>
</tr>
<tr>
<td>Other</td>
<td>1.5</td>
<td>1.2</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>No health insurance (%)</td>
<td>0.5</td>
<td>1.7</td>
<td>1.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

“Insurance coverage” reflects coverage at any point during the year, thus these categories are not mutually exclusive (except for the “no health insurance” option).

<table>
<thead>
<tr>
<th>Additional Insurance Information in 2018</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals who participated in a patient assistance program (%)</td>
<td>42.8</td>
</tr>
<tr>
<td>Individuals 18 to 25 years covered under parents’ insurance (%)</td>
<td>54.4</td>
</tr>
</tbody>
</table>

“Patient assistance program” refers to any program that provides free medication or co-pay assistance.

A large proportion of children with CF use Medicaid or state programs, including 56.0 percent of children aged younger than 10 years. Though the overall prevalence of Medicare use is low, among adults aged 30 to 35 years, 22.1 percent report Medicare coverage. This increases to 27.9 percent among adults aged 40 to 64 years. Individuals aged younger than 65 years who receive Medicare have met the federal criteria for disability.
DIAGNOSIS

Diagnostic Characteristics of Individuals with CF

This section examines characteristics of individuals diagnosed with CF, as well as trends over time for two key diagnostic tests: genotyping and sweat test.

In 2018, 61.5 percent of total new diagnoses and 86.6 percent of diagnoses among those less than 6 months old were reported as being detected by newborn screening (NBS). There is evidence that individuals diagnosed prior to the onset of symptoms have better lung function and nutritional outcomes later in life. Diagnosis in the newborn period also represents an important opportunity for CF care centers to partner with community physicians and families to ensure the best possible care and outcomes for infants with CF.

With the widespread use of NBS for CF, it was necessary to develop terminology for individuals with a positive NBS who have inconclusive sweat test results and/or fewer than two CF-causing genetic mutations. In the United States, this is referred to as CFTR-related metabolic syndrome (CRMS); other countries use the term CF screen positive, inconclusive diagnosis (CFSPID). Recently released diagnosis guidelines harmonized the criteria for CRMS/CFSPID. CRMS was added to the Registry as a diagnostic option in 2010. Entry of a diagnosis of CF versus CRMS into the Registry is a clinical decision; there is no requirement that individuals meet published diagnostic criteria for CF or CRMS. The percentage of CRMS/CFSPID increased from 12.7 percent of those diagnosed during the year in 2017 to 14.1 percent in 2018.
Individuals can be diagnosed with CFTR-related disorder. This option has also been available in the Registry since 2010. Individuals with this diagnosis do not meet diagnostic criteria for CF or CRMS, are affected by CF-related conditions such as congenital bilateral absence of the vas deferens (CBAVD), and often have mutations in the CFTR gene. The percentage of individuals reported to have CFTR-related disorder increased from 75 (6.1 percent of those diagnosed during the year in 2017) to 93 (8.5 percent) in 2018, potentially due to increased awareness of the option of reporting it to the Registry. Collection and analysis of data from individuals with CRMS and CFTR-related disorder will provide new and important information for these distinct populations.

In 2018, 575 newborn infants were diagnosed with CF. Of those with a known gestational age at birth, 90.2 percent were born full-term, comparable with the figure for the general U.S. population. The mean birth weight for full-term infants with CF is also about the same as for the U.S. population, suggesting that babies born with CF do not initially show nutritional deficiencies. The graph does not include the 127 infants who were diagnosed with CF in 2018 and did not have a gestational age recorded in the Registry (22.1 percent).

“Preterm” refers to infants born at a gestational age less than 37 weeks. “Full term” refers to infants born at a gestational age greater than or equal to 37 weeks.
The majority of those diagnosed in their first year are asymptomatic or minimally symptomatic at time of diagnosis. Among the 11.9 percent of infants diagnosed in 2018 before age one with meconium ileus (or other intestinal obstruction), 30.1 percent had bowel perforation. Since the number of infants with meconium ileus is small, the percentage with bowel perforation fluctuates year to year, which may explain why the percentage is higher this year than typically reported. Those diagnosed after age one often present with acute or persistent respiratory abnormalities.

### Symptoms Reported at CF Diagnosis

<table>
<thead>
<tr>
<th>Symptoms Reported at CF Diagnosis</th>
<th>All individuals (%)</th>
<th>Diagnosed in 2018 (%)</th>
<th>Diagnosed in 2018 Age &lt; 1 (%)</th>
<th>Diagnosed in 2018 Age ≥ 1 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Individuals (n)</td>
<td>30,775</td>
<td>852</td>
<td>612</td>
<td>240</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNA analysis</td>
<td>12.5</td>
<td>24.7</td>
<td>24.4</td>
<td>25.4</td>
</tr>
<tr>
<td>Family history</td>
<td>14.4</td>
<td>10.9</td>
<td>9.8</td>
<td>13.8</td>
</tr>
<tr>
<td>Newborn (neonatal) screening</td>
<td>26.4</td>
<td>61.5</td>
<td>83.3</td>
<td>N/A</td>
</tr>
<tr>
<td>Prenatal screening (CVS, amniocentesis)</td>
<td>2.4</td>
<td>4.5</td>
<td>6.2</td>
<td>N/A</td>
</tr>
<tr>
<td>Symptomatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute or persistent respiratory abnormalities</td>
<td>35.3</td>
<td>13.5</td>
<td>2.1</td>
<td>42.5</td>
</tr>
<tr>
<td>CBAVD or infertility/GU abnormalities</td>
<td>0.6</td>
<td>2.5</td>
<td>0.0</td>
<td>8.8</td>
</tr>
<tr>
<td>Digital clubbing</td>
<td>0.5</td>
<td>1.4</td>
<td>0.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Edema</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Electrolyte imbalance</td>
<td>2.9</td>
<td>0.4</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Failure to thrive/malnutrition</td>
<td>27.3</td>
<td>5.3</td>
<td>4.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Liver problems</td>
<td>1.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Meconium ileus/other intestinal obstruction</td>
<td>17.1</td>
<td>9.3</td>
<td>11.9</td>
<td>N/A</td>
</tr>
<tr>
<td>Nasal polyps/sinus disease</td>
<td>3.6</td>
<td>3.3</td>
<td>0.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Rectal prolapse</td>
<td>2.6</td>
<td>0.2</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Steatorrhea/abnormal stools/malabsorption</td>
<td>20.9</td>
<td>3.1</td>
<td>2.1</td>
<td>5.4</td>
</tr>
<tr>
<td>Other</td>
<td>4.7</td>
<td>5.9</td>
<td>2.0</td>
<td>15.8</td>
</tr>
</tbody>
</table>

Data are not mutually exclusive. We anticipate that additional 2018 diagnoses will be entered into the Registry in 2019.

A. Chorionic villus sampling
B. Congenital bilateral absence of the vas deferens
C. Genitourinary
Among all individuals in the Registry in 2018, 66.7 percent were diagnosed in the first year of life.

**Diagnostic Tests**

**Sweat Chloride Testing**

Sweat chloride testing is an important diagnostic test recommended for all individuals regardless of genotype. In 2018, 89.8 percent of individuals in the Registry had a sweat chloride test result recorded. Individuals who are homozygous for F508del, the most common CF-causing genetic mutation, are less likely to have sweat chloride values in the Registry than those with other mutations. Baseline sweat chloride tests are becoming more important, as changes in sweat chloride are now viewed as indicators of the physiological effects of CFTR modulators.
Median sweat chloride test results have remained consistent over time for individuals who are F508del homozygous. In contrast, there has been a steady decline in median sweat chloride values among individuals who are not homozygous for F508del, suggesting that more individuals with “less severe” genotypes are being entered into the Registry.

**Genotyping**

The cystic fibrosis transmembrane conductance regulator (CFTR) gene and the most prevalent CF-causing mutation (F508del) were discovered in 1989. Since then, genotyping has become a key component of the diagnostic work-up. In addition, with the introduction of CFTR modulators, genotyping all people with CF is important for research and clinical care. In 2018, 98.2 percent of individuals (n=30,230) in the Registry had been genotyped.
**CFTR GENE MUTATIONS**

To date, more than 1,800 mutations have been found in the CFTR gene.\(^1\) Some mutations result in virtually no CFTR function and others are associated with some residual function. Various strategies have been used to categorize mutations with the goal of grouping individuals with CF with a similar prognosis. In previous reports, a five-mutation class system was used.\(^2\)\(^-\)\(^4\) This classification system is helpful for understanding the impact of mutations on the biosynthesis and function of the CFTR protein. However, it is increasingly recognized that this classification schema is an oversimplification. The figure below illustrates the complexity in grouping mutations into distinct classes. Note that many mutations lead to more than one defect in CFTR function.

![Classification of CFTR Mutations](image)

*This diagram indicates all combinations of mutation classes with selected examples. Possible combinations without identified mutation are indicated in gray. Source: Veit et al.\(^5\)*

In this era of CFTR modulators, a second approach is being evaluated for mutation classification, referred to as theratyping. This system considers whether a mutation responds to a specific CFTR modulator. One approach is to group individuals with CF into four groups: the 13.6 percent of individuals with mutations that respond to a potentiator (ivacaftor), the 44.1 percent of individuals with mutations that respond to a potentiator/corrector combination (lumacaftor/ivaftor or tezacaftor/ivacaftor), the 24.1 percent of individuals with mutations that are currently non-responsive to available therapies, and the remaining 18.2 percent of individuals who have mutations that have not yet been tested for responsiveness to therapies. Theratyping is still in progress and there is not yet a standard way to report this information. As such, all tables and figures in this report will combine individuals regardless of mutation.
The most common CFTR mutation is F508del: 84.7 percent of individuals in the Registry who have been genotyped have at least one copy of this mutation. There is a substantial drop in prevalence from F508del to the next most common mutations. No other mutation is currently found in more than 5 percent of the population with CF.

### Prevalence of the 25 Most Common CFTR Mutations in People with CF Seen in 2018

<table>
<thead>
<tr>
<th>CFTR Mutation</th>
<th>Number of Individuals</th>
<th>Percent of Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>L507del</td>
<td>241</td>
<td>0.8</td>
</tr>
<tr>
<td>3272-26A&gt;G</td>
<td>236</td>
<td>0.8</td>
</tr>
<tr>
<td>2184insA</td>
<td>231</td>
<td>0.8</td>
</tr>
<tr>
<td>R1162X</td>
<td>229</td>
<td>0.7</td>
</tr>
<tr>
<td>1898+1G&gt;A</td>
<td>213</td>
<td>0.7</td>
</tr>
<tr>
<td>3659delC</td>
<td>208</td>
<td>0.7</td>
</tr>
<tr>
<td>G85E</td>
<td>201</td>
<td>0.7</td>
</tr>
<tr>
<td>L206W</td>
<td>188</td>
<td>0.6</td>
</tr>
<tr>
<td>R347P</td>
<td>183</td>
<td>0.6</td>
</tr>
<tr>
<td>A455E</td>
<td>172</td>
<td>0.6</td>
</tr>
<tr>
<td>R334W</td>
<td>172</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The number and percentage of individuals with a given mutation include those with one or two copies of the mutation.
Among less common mutations, the number of individuals with an R117H mutation has increased over the years. Among those genotyped in 1993, less than 1 percent had an R117H mutation, compared with 4.8 percent of those genotyped in 2018. This may be due to the inclusion of R117H in newborn screening algorithms. Of note, 102 (11.1 percent) of the 921 individuals with an R117H mutation had a sweat chloride value less than 30 mmol/L.

The clinical significance of the R117H mutation depends in part on the poly-T tract variant on the chromosome. Research indicates that a shorter poly-T tract is associated with a higher likelihood of having CF.16,17 Unfortunately, the Registry has incomplete information on the poly-T tract status for the majority of individuals (62.1 percent) who are reported as having a diagnosis of CF and an R117H mutation. Of the 349 individuals with poly-T tract status recorded in the Registry, 127 (36.4 percent) are classified as having 5T.
Individuals with mutations typically associated with little or no CFTR function tend to be younger, to have higher sweat test values, and to be more likely to be prescribed pancreatic enzyme replacement therapies (PERT) than individuals with a mutation typically associated with residual CFTR function (e.g., 97.2 percent of individuals with the former as compared to 34.5 percent of the latter are taking PERT).

<table>
<thead>
<tr>
<th>Sweat Chloride Value (mmol/L), by Genotypes</th>
<th>0</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>Median</th>
<th>5th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals with mutations associated with little or no CFTR function N=18,757</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>102.0</td>
<td>79.0</td>
<td>127.0</td>
</tr>
<tr>
<td>Individuals with one or more mutations associated with residual CFTR function N=3,392</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71.0</td>
<td>28.0</td>
<td>113.0</td>
</tr>
<tr>
<td>Individuals with one or more unclassified mutations N=4,494</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>92.0</td>
<td>39.0</td>
<td>122.0</td>
</tr>
<tr>
<td>All individuals N=26,643</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>99.0</td>
<td>51.0</td>
<td>125.0</td>
</tr>
</tbody>
</table>

*These charts use the highest sweat test value reported to the Registry. For some individuals, this value may reflect sweat chloride values after initiation of CFTR modulator therapy.*
GUIDELINES: CARE, SCREENING, AND PREVENTION

The CF Foundation sponsors the development of clinical practice guidelines to promote high-quality physical and mental health care for individuals with CF during infancy, childhood, and adulthood. Many CF care centers report four office visits, two pulmonary function tests, and at least one microbiology culture annually for the majority of their CF patients. Similarly, among children aged 2 to 5, the majority have at least four visits and at least one culture each year.

CF care centers report that respiratory therapists/physical therapists, dietitians/nutritionists, and social workers evaluate most of their patients at least once per year, as recommended.

There is significant variation by CF care center in several key screening measures, including dual-energy X-ray absorptiometry (DXA) scans for osteopenia/osteoporosis. The influenza vaccination rate for people with CF aged six months and older remains high across the CF care center network. Smoking and secondhand smoke exposure remain challenges, particularly for infants and young adults.

Patient Care Guidelines

The percentage of individuals who receive care that meets CF Foundation care guidelines has gradually increased. Because individuals should be able to perform reliable pulmonary function tests (PFTs) at age six and older, we use guidelines criteria for those age seven and older to ensure that individuals were eligible to perform a reliable PFT for the entire year.

Over the past decade, the number of children and adults receiving, at a minimum, the annual recommended four office visits, four respiratory cultures, and two PFTs has steadily increased. The percentage of adults who receive care that meets guidelines criteria remains lower than that observed in children. However, the percentage of those meeting guidelines continues to rise. Currently, more than half of adults are being seen at least four times, complete two or more PFTs, and are cultured at least once during the year. Many elements may impact metrics, such as the fact that some stable individuals may not need face-to-face encounters in the clinic setting.
The guidelines on infection prevention and control recommend that individuals with CF have quarterly respiratory cultures. In 2018, 98.6 percent of individuals received at least one culture, and 55.0 percent of individuals had four or more respiratory cultures. Those aged younger than 18 were more likely to meet the recommendation for four cultures.

The multidisciplinary care team plays an important role in CF care. Over time, there has been an increase in the number of individuals with CF who receive an annual evaluation from a respiratory/physical therapist, dietitian/nutritionist, and social worker. In 2018, 80.1 percent of individuals were evaluated by all three specialists. In addition, to support individuals’ complex treatment regimens, the Registry now reports whether patients are seen by a pharmacist in clinic. In 2018, 39.2 percent of individuals were seen by a pharmacist.
The CF Foundation recommends the inclusion of a mental health professional as part of the CF care team. Information on screening for anxiety and depression is included in the Complications section (page 67).

The Centers for Disease Control and Prevention's Advisory Committee on Immunization Practices recommends influenza vaccination for all individuals with CF aged six months and older. The influenza vaccination rate of people with CF aged six months and older is 75.8 percent of the total population and 88.5 percent of those with a known vaccination status (excluding 14.4 percent with unknown status).
The CF Foundation consensus statement on bone health and disease recommends screening all adults with CF with a DXA scan and subsequent follow-up based on the findings of the baseline scan. Annual screenings are recommended only for individuals with DXA z-scores that are lower than two standard deviations below the mean, with less frequent screening recommended for those with higher values. Therefore, in the figure below, we group five years of data.

<table>
<thead>
<tr>
<th>Percentage of Individuals with a DXA Scan in the Past Five Years, by Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Individuals 18 Years and Older</td>
</tr>
</tbody>
</table>

*Includes any DXA scans performed during 2014–2018.*

CF Foundation guidelines recommend annual measurement of fat-soluble vitamins to screen for vitamin deficiency. The CF Foundation Hepatobiliary Disease Consensus Group recommends a yearly panel of liver blood tests for all people with CF to screen for possible liver disease. Registry data suggest that these tests are being done on the majority of individuals.

<table>
<thead>
<tr>
<th>Percentage of Individuals Screened by or Monitored with Annual Labs, by Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Individuals with Fat-Soluble Vitamins Measured</td>
</tr>
<tr>
<td>Individuals with Liver Enzymes Measured</td>
</tr>
</tbody>
</table>
Tobacco smoke and secondhand smoke exposure remain significant concerns, especially for infants and young adults. In 2018, 17.0 percent of individuals with CF reported monthly or more frequent exposure to tobacco smoke, either secondhand or as a smoker. Cigarette smoking prevalence is lower in the CF population than in the general U.S. population; 2.1 percent of adults with CF are smokers, compared with 16.9 percent in the general population in 2017. Smoke exposure was unknown for 36.8 percent of individuals with CF, who were excluded from the analyses.
Infant Care Guidelines

The CF Foundation recommends that evaluation and treatment of infants detected by newborn screening should be done at a CF Foundation-accredited care center, with the goal of an initial visit within 24 to 72 hours of diagnosis. It is important to make a definitive diagnosis as quickly as possible to minimize the stress and uncertainty for families. For those diagnosed with CF, families can be educated about the disease and treatment can be started.\(^5\) It is encouraging that 88.7 percent of infants diagnosed in 2018 have their first clinic encounter, genotyping, or sweat test within 30 days of birth.

The CF Foundation infant care guidelines recommend monthly CF care center visits during the first six months of life and every one to two months in the second six months.\(^5\) Therefore, we expect infants with CF detected by NBS to have 9 to 12 visits in the first year of life. There is marked variation in the number of encounters for individuals in the first year of life across the CF care center network.

This chart shows data for children born in 2017 because a full year of data is available for these individuals. Median time to first sweat test for these individuals is 29 days. In 2017, 28 infants (5.3 percent) who were detected by NBS did not have a sweat chloride test reported to the Registry by the end of 2018 and thus were excluded from this analysis.
Respiratory cultures are being collected at the majority of clinic visits for infants with CF. Infant care guidelines recommend that cultures be performed at least quarterly during the first two years of life.\(^5\)

The chart shows data for children born in 2017 because a full year of data is available for these individuals. The median number of visits in the first year of life is nine.

The chart shows data for children born in 2017 because a full year of data is available for these individuals. The median number of cultures in the first year of life is six.
Fecal elastase testing, which provides an objective measure of pancreatic function, is recommended in the infant care guidelines. There is marked variation in the use of this test across the CF care center network. The guidelines also recommend that infants begin salt supplementation after diagnosis, and this is widely followed across the CF care center network. We observe substantial variation in the utilization of palivizumab (respiratory syncytial virus, or RSV prophylaxis) across the CF care center network, with a downward trend since 2008. The current American Academy of Pediatrics recommendation is that palivizumab should not be routinely used in individuals with CF. The CF Foundation infant care guidelines recommend that its use be considered for infants with CF.

### Infant Care Guidelines, by Center

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>100</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal Elastase Value Reported for Individuals Less Than 24 Months</td>
<td></td>
<td></td>
<td></td>
<td>68.8</td>
<td>6.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Salt Supplementation in Individuals Less Than 24 Months</td>
<td></td>
<td></td>
<td></td>
<td>100.0</td>
<td>78.6</td>
<td>100.0</td>
</tr>
<tr>
<td>RSV Prophylaxis in Individuals Less Than 24 Months</td>
<td></td>
<td></td>
<td></td>
<td>10.0</td>
<td>0.0</td>
<td>53.3</td>
</tr>
</tbody>
</table>

### Testing and Therapies for Individuals Under 24 Months of Age, 2011-2018

- **Salt Supplementation Reported**
- **Fecal Elastase Value Reported**
- **RSV Prophylaxis Reported**

![Graph showing the percentage of individuals receiving therapies from 2011 to 2018](chart.png)
MICROBIOLOGY

This section provides information on trends in CF airway pathogens over time and by age group for individuals who never received a lung transplant. Infection prevention and control guidelines provide current best practices for reducing exposure to CF pathogens in the health care setting and in everyday life.\textsuperscript{31}

The prevalence of \textit{Pseudomonas aeruginosa} (\textit{P. aeruginosa} or PA) continues to decrease. This may relate in part to widespread implementation of therapy to eradicate initial acquisition.\textsuperscript{22,31} Despite this, the prevalence of infection with multidrug-resistant \textit{P. aeruginosa} (MDR-PA) has remained constant.

Some of the increase in \textit{Staphylococcus aureus} (\textit{S. aureus}) may be due to improved microbiologic practices for detection and reporting of Gram-positive organisms. From 2000 to 2010, there was a significant increase in the number of individuals with CF with a positive culture for methicillin-resistant \textit{S. aureus} (MRSA). Since 2010, prevalence appears to have plateaued. The stabilization of prevalence is potentially due to increased awareness and infection prevention and control strategies.
The graph shows the proportion of individuals in various age groups who cultured positive for the bacterial species indicated during 2018.

A note about the reporting of *Burkholderia* species: in 2018, 2.6 percent of those cultured were reported in the Registry as having had a culture positive for *Burkholderia cepacia* (*B. cepacia*) complex. Further investigation is needed on the reporting practices for *B. cepacia* complex subspecies before figures on these variables can be included in the report.

The microorganisms observed in bacterial cultures change as individuals age. Even at very young ages, more than 60 percent of individuals have at least one microorganism and this increases to more than 80 percent in older ages. *S. aureus* is the most common microorganism overall and, as individuals age, it is commonly observed in concert with *P. aeruginosa*.
Pseudomonas aeruginosa

The percentage of individuals with a positive culture for *P. aeruginosa* has continued to decline over time, with the largest decrease observed among individuals younger than 18 years (46.2 percent had a positive culture in 1998 compared with 26.2 percent in 2018). Many individuals with CF now transition to adult care without *P. aeruginosa* in their respiratory tract.

Rates of MDR-PA infection are greatest in older adolescents and adults with CF. This finding likely reflects cumulative exposure to antibiotics. The clinical significance of this drug resistance is unclear. Among the individuals with CF who had at least one bacterial culture in 2018, 7.5 percent were reported to have MDR-PA. Among the individuals with CF with a *P. aeruginosa* infection in 2018, 16.9 percent were reported to have MDR-PA.

Multidrug resistance is defined as resistance to all antibiotics tested in two or more classes in a single culture.
A classification system known as the Leeds criteria is used to categorize individuals on the basis of *P. aeruginosa* infection status. The Leeds criteria categories are “never having a positive *P. aeruginosa* culture,” “free of a positive *P. aeruginosa* culture in the past 12 months,” “intermittent infection” (less than 50 percent of their cultures in the past year were positive for *P. aeruginosa*), and “chronic infection” (more than 50 percent of their cultures in the past year were positive for *P. aeruginosa*).

### *P. aeruginosa* Status Using Leeds Criteria, 2018

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never Cultured Positive</td>
<td>20.6%</td>
</tr>
<tr>
<td>Cultured Negative (previously positive)</td>
<td>31.5%</td>
</tr>
<tr>
<td>Cultured Positive</td>
<td>45.3%</td>
</tr>
<tr>
<td>Not Cultured</td>
<td>2.6%</td>
</tr>
<tr>
<td>Intermittent PA</td>
<td>17.0%</td>
</tr>
<tr>
<td>Chronic PA</td>
<td>28.3%</td>
</tr>
</tbody>
</table>

---

**Staphylococcus aureus**

Overall, more than half of individuals had at least one culture positive for methicillin-sensitive *S. aureus* (MSSA) in 2018. This chart shows that the highest prevalence of MRSA occurs in individuals between the ages of 10 and 30, while MSSA peaks among those younger than 10.

### MSSA and MRSA by Age in Years, 2018

![Chart showing MSSA and MRSA by age]
Nontuberculous Mycobacteria

Prevalence of nontuberculous mycobacteria (NTM) infections is increasing in the general population. Since 2010, the Registry has collected more robust information on mycobacterial cultures and NTM infections.

The CF Foundation/European Cystic Fibrosis Society Guidelines Committee recommends that individuals with CF who are able to expectorate be cultured for NTM infections annually. Individuals should also be screened before and six months after beginning azithromycin and annually thereafter. The data show improvement in screening rates over time, but wide variation by CF care center persists in these measures.

### Percentage of Individuals with a Mycobacterial Culture, by Center

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>100</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals Who Produced a Sputum Sample During the Year</td>
<td></td>
<td></td>
<td></td>
<td>76.8</td>
<td>18.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Individuals Taking a Chronic Macrolide Who Produced a Sputum Sample During the Year</td>
<td></td>
<td></td>
<td></td>
<td>82.4</td>
<td>42.4</td>
<td>100.0</td>
</tr>
</tbody>
</table>

A throat swab is insufficient for a mycobacterial culture, so an individual must be able to produce sputum for this culture to be performed. A majority (78.7 percent) of the individuals who produced a sputum culture for a bacterial culture also had a mycobacterial culture performed during the year.

### Sputum Produced and Mycobacterial Cultures by Age in Years, 2018

- **All Individuals**
- **Sputum Produced**
- **Mycobacterial Culture Performed**
Of the 15,067 individuals who had a mycobacterial culture performed in 2018, 2,055 (13.6 percent) had a mycobacterial species isolated one or more times. The relative proportion of *M. abscessus* isolated in 2018 is higher than reported more than a decade ago in a CF Foundation-supported multicenter prevalence study.\(^\text{34}\)

**Mycobacterial Species Isolated in 2018**

<table>
<thead>
<tr>
<th>Mycobacterial Species</th>
<th>Number of Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. avium complex</em> (MAC)</td>
<td>1009</td>
</tr>
<tr>
<td><em>M. abscessus</em>/<em>M. chelonae</em></td>
<td>860</td>
</tr>
<tr>
<td><em>M. gordonae</em></td>
<td>51</td>
</tr>
<tr>
<td><em>M. fortuitum</em></td>
<td>35</td>
</tr>
<tr>
<td><em>M. tuberculosis</em></td>
<td>13</td>
</tr>
<tr>
<td><em>M. kansasii</em></td>
<td>6</td>
</tr>
</tbody>
</table>

Data are not mutually exclusive. Some individuals had more than one species isolated in 2018.
NUTRITION

Nutritional outcomes are a key measure of health in people with CF. This section is divided into three age groups to report nutrition metrics: infants younger than 2 years, children 2 to 19 years, and adults 20 years and older for individuals who never received a lung transplant. Overall improvements in nutritional metrics are observed for all ages. Recent CF Foundation evidence-informed guidelines recommend enteral tube feeding as a means to improve age-dependent anthropometrics and nutrition in individuals with CF who are unable to consume adequate nutrition to meet goals.\(^{36}\)

Goals for CF Foundation weight-for-length and BMI percentile in children are based on CDC growth curves. However, the CDC and the American Academy of Pediatrics recommend the use of World Health Organization (WHO) growth curves, for children less than 24 months of age.\(^ {37}\) WHO growth curves are used to report the data below.
The following charts show the population-level variation in infants for WHO weight-for-length, weight, and length percentiles by age. As would be expected for a large population, there is substantial variation observed for all three metrics. The median values for weight-for-length and BMI percentile are above the recommendation of 50th percentile. However, we still see evidence that infants’ and children’s growth is below what is expected for the U.S. population.

### All Individuals, WHO Nutritional Outcomes for Infants Under 24 Months

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>100 Median</th>
<th>5th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight-for-Length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=1,768</td>
<td></td>
<td></td>
<td></td>
<td>64.0</td>
<td>15.6</td>
</tr>
<tr>
<td>Weight Percentile</td>
<td></td>
<td></td>
<td></td>
<td>43.3</td>
<td>2.9</td>
</tr>
<tr>
<td>N=1,768</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length Percentile</td>
<td></td>
<td></td>
<td></td>
<td>30.0</td>
<td>1.0</td>
</tr>
<tr>
<td>N=1,768</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The goal established by the CF Foundation nutrition guidelines for children age 2 to 19 years is a BMI percentile at or above 50 using CDC growth curves.\(^\text{26}\) The median BMI percentile is above the 50th percentile; however, length percentile remains well below that of the general population.

### All Individuals, CDC Nutritional Outcomes for Individuals 2 to 19 Years

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>100 Median</th>
<th>5th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI Percentile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=14,041</td>
<td></td>
<td></td>
<td></td>
<td>57.6</td>
<td>10.0</td>
</tr>
<tr>
<td>Weight Percentile</td>
<td></td>
<td></td>
<td></td>
<td>48.6</td>
<td>4.3</td>
</tr>
<tr>
<td>N=14,145</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height Percentile</td>
<td></td>
<td></td>
<td></td>
<td>37.6</td>
<td>2.2</td>
</tr>
<tr>
<td>N=14,145</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For individuals born between 1989 and 2008, we observed improved weight and height percentiles with successive birth cohorts. For height, the most notable improvements were seen in the youngest cohorts. More recently, there is less change between cohorts. This is potentially a result of the stabilization of improvements observed from early intervention due to newborn screening.\textsuperscript{18,39}
The BMI goal established by the CF Foundation nutrition guidelines is at or above 22 for women and 23 for men aged 20 years and older. Improvements in nutrition and dietary interventions have substantially decreased the percentage of adults that are currently malnourished, defined as a BMI less than 18.5 (7.2 percent in 2018 compared 18.6 percent in 1998). However, currently, 30.0 percent of adults have a BMI in the range categorized by CDC as overweight (22.3 percent) or obese (7.7 percent), with a higher prevalence in men (34.0 percent) than women (25.5 percent).

<table>
<thead>
<tr>
<th>BMI Value for Adults 20 Years and Older</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>All Individuals</td>
</tr>
<tr>
<td>N=13,589</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>22.9</td>
</tr>
<tr>
<td>5th Percentile</td>
</tr>
<tr>
<td>17.9</td>
</tr>
<tr>
<td>95th Percentile</td>
</tr>
<tr>
<td>31.8</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>N=6,406</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>22.3</td>
</tr>
<tr>
<td>5th Percentile</td>
</tr>
<tr>
<td>17.8</td>
</tr>
<tr>
<td>95th Percentile</td>
</tr>
<tr>
<td>32.8</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>N=7,183</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>23.3</td>
</tr>
<tr>
<td>5th Percentile</td>
</tr>
<tr>
<td>18.1</td>
</tr>
<tr>
<td>95th Percentile</td>
</tr>
<tr>
<td>31.2</td>
</tr>
</tbody>
</table>

Significant progress in nutritional outcomes continues for all people with CF. Aging of the CF population and a greater number of late diagnoses with genotypes associated with milder disease may be contributing to the trend in adult nutritional outcomes shown below.
Infant Feeding

The majority of infants with CF receive formula feeding as the primary form of feeding or as a supplement to breastfeeding. Cow’s milk-based formula with the standard caloric density of 20 calories per ounce is the most common feeding used from birth to age 3 months. More calorie-dense formulas are used after 3 months of age. CF Foundation infant care guidelines recommend human breast milk or standard infant formula as the initial form of feeding. Fortified human breast milk, calorie-dense formulas, or complementary foods are recommended if the infant is failing to gain weight adequately.²

Infants may be included in more than one age category. They may also be counted more than once within an age category if different forms of feeding were recorded during separate clinic visits while within the same age category.
PULMONARY AND NUTRITIONAL OUTCOMES

Pulmonary and nutritional outcomes are two key measures of CF health. These metrics are the primary focus of quality improvement work within the CF care center network. The data show that for all people with CF, better pulmonary function, and higher BMI percentile are associated.

Pulmonary and nutritional goals are as follows:

- For children, FEV\textsubscript{1} percent predicted greater than or equal to 100, and BMI percentile meeting or exceeding the 50th percentile.
- For adults, FEV\textsubscript{1} percent predicted greater than or equal to 75, and BMI value greater than or equal to 22 for women and 23 for men.

![FEV\textsubscript{1} Percent Predicted vs. BMI Percentile for Children 6 to 19 Years in 2018](image1)

Goal: 50th percentile

![FEV\textsubscript{1} Percent Predicted vs. BMI Value for Adults 20 to 40 Years in 2018](image2)

Goal: 22 for Women
23 for Men
The figures below on the left show median BMI percentile and FEV₁ percent predicted values for each center in 2018. The figures on the right show how median values for all centers have improved over the last 30 years.
PULMONARY FUNCTION

Pulmonary function is an important clinical indicator of the health of individuals with CF. This section provides information on trends in pulmonary function by age for individuals who have never had an organ transplant, as well as variations in pulmonary function across CF care centers. Pulmonary function is measured using the FEV₁ percent predicted and calculated using the Global Lung Initiative (GLI) reference equations.¹

Successive birth cohorts show improved pulmonary function across all ages for individuals who are old enough to perform reliable pulmonary function testing. The majority of those aged 18 years now have an FEV₁ percent predicted greater than or equal to 70.

FEV₁ percent predicted is steadily improving and currently is above 90 percent predicted into early adolescence.
The proportion of people with CF aged 18 who are in the normal/mild lung disease category (FEV$_1$ ≥70 percent predicted) has increased from 37.6 percent in 1988 to 71.5 percent in 2018. The proportion in the severe lung disease category (FEV$_1$ <40 percent predicted) has decreased from 24.2 percent in 1988 to 3.9 percent in 2018.

It is important to point out that spirometry is not a sensitive measure of early lung disease in CF. With that caveat in mind, the vast majority of children have normal or “mild” impairment in pulmonary function. This proportion decreases until age 45, when the population has nearly equal proportions of individuals with mild, moderate, and severe lung disease.

### Median FEV$_1$, Percent Predicted in 18-Year-Olds, 1988–2018

<table>
<thead>
<tr>
<th>Year</th>
<th>FEV$_1$ Normal(≥90%)</th>
<th>FEV$_1$ Mild (70% to 89%)</th>
<th>FEV$_1$ Moderate (40% to 69%)</th>
<th>FEV$_1$ Severe (&lt;40%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pulmonary Function Impairment by Age in Years, 2018 (Stacked Bar Chart)
The median FEV$_1$ percent predicted among individuals aged 6 to 17 is 94.3 percent. About half of the adults have an FEV$_1$ percent predicted that is greater than 70.0 percent, representing mild disease. However, a wide variation in lung function is observed among adults with a quarter having a FEV$_1$ percent predicted less than 50.0 percent.

<table>
<thead>
<tr>
<th>FEV$_1$ Percent Predicted</th>
<th>0</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>125</th>
<th>Median</th>
<th>5th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Individuals 6 to 17 Years</td>
<td>N=9,411</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>94.3</td>
<td>60.3</td>
<td>116.9</td>
</tr>
<tr>
<td>All Individuals 18 Years and Older</td>
<td>N=14,645</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.4</td>
<td>29.0</td>
<td>105.8</td>
</tr>
</tbody>
</table>
Pulmonary Exacerbations

Pulmonary exacerbations, characterized by intravenous (IV) antibiotic treatment in the hospital or at home, are associated with morbidity, mortality, and decreased quality of life. They are also a major driver of health care costs. This section displays trends in the rate of pulmonary exacerbations over time and by age group among individuals who never had an organ transplant, as well as variation in exacerbation rates and treatment characteristics by CF care center.

Despite notable improvements in pulmonary function and nutritional status over the years, there has not been a marked change in the proportion of individuals with CF who are treated with IV antibiotics for pulmonary exacerbations. This suggests that clinicians are more aggressively prescribing IV antibiotics to healthier individuals.

Individuals with CF who are between ages 15 and 30 are more likely than those in other age groups to experience a pulmonary exacerbation during the year.
When the CF Foundation developed guidelines for the treatment of pulmonary exacerbations in 2009, little published literature or data were available upon which to base recommendations. Current practice within the CF Foundation care center network indicates a median treatment duration of about two weeks, with adults more likely to complete some of their treatment at home. Further research is underway to develop evidence for best practices in the treatment of pulmonary exacerbations.

### Duration of Pulmonary Exacerbation Treatment in Days, by Center

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30 Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Total Duration of IV Antibiotic Treatment for a Pulmonary Exacerbation in Individuals Less than 18 Years</td>
<td></td>
<td></td>
<td></td>
<td>13.0</td>
<td>6.5</td>
<td>17.5</td>
</tr>
<tr>
<td>Median Duration of Hospital Stay for Treatment of a Pulmonary Exacerbation in Individuals Less than 18 Years</td>
<td></td>
<td></td>
<td></td>
<td>10.0</td>
<td>3.0</td>
<td>15.5</td>
</tr>
<tr>
<td>Median Total Duration of IV Antibiotic Treatment for a Pulmonary Exacerbation in Individuals 18 Years and Older</td>
<td></td>
<td></td>
<td></td>
<td>14.0</td>
<td>9.5</td>
<td>18.0</td>
</tr>
<tr>
<td>Median Duration of Hospital Stay for Treatment of a Pulmonary Exacerbation in Individuals 18 Years and Older</td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
<td>3.0</td>
<td>14.0</td>
</tr>
</tbody>
</table>

### Percentage of Total Pulmonary Exacerbation Treatment Duration in Hospital, by Center

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>100 Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals Less than 18 Years</td>
<td></td>
<td></td>
<td>86.5</td>
<td>37.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Individuals 18 Years and Older</td>
<td></td>
<td></td>
<td>61.9</td>
<td>15.1</td>
<td>100.0</td>
</tr>
</tbody>
</table>
THERAPIES

Gastrointestinal (GI) Therapies

The CF Foundation infant clinical care guidelines recommend that pancreatic enzyme replacement therapies (PERT) be started for all infants with two CFTR mutations associated with pancreatic insufficiency, a fecal elastase value below 200 μg/g of stool, and/or signs of malabsorption.

A large proportion of individuals of all ages are prescribed PERT. The decrease in the proportion of older individuals with CF prescribed PERT is most likely due to individuals with “milder” genotypes surviving longer.

For individuals age two years and older, the recommended upper limit for enzyme dosing is 2,500 lipase units/kg/meal and a total of 10,000 lipase units/kg/day. The mean dose of lipase units/kg/meal for individuals 2 to 19 years is 1,943 and for individuals 20 years and older, the mean dose is 1,786, suggesting that children and adults on average are receiving a sufficient dosage of PERT.

Infants with evidence of pancreatic insufficiency are recommended to receive 2,000 to 5,000 lipase units per feeding (total lipase dose), with adjustments as the infant grows. Registry data show that the mean highest dose of lipase among children younger than two years is 1,677 units/kg/meal, suggesting that infants may not be receiving an adequate dosage of PERT, or that there is some residual pancreatic function in younger individuals.

For infants with CF younger than two years, the infant clinical care guidelines recommend assessment of pancreatic functional status by measurement of fecal elastase. Data on fecal elastase test results have been collected in the Registry since 2010, with an increased number of individuals undergoing fecal elastase testing. About 64.5 percent of infants born in 2018 were tested and have a fecal elastase value. Among individuals with a clinic visit aged younger than two in 2018, 32.3 percent did not have a fecal elastase value reported. Of those not tested, 87.6 percent were prescribed PERT. Almost all individuals with a known fecal elastase value of less than 200 μg/g of stool were prescribed PERT. Approximately 23.7 percent of individuals with fecal elastase values greater than or equal to 200 μg/g of stool were also prescribed PERT.
Acid blockers are commonly prescribed for people with CF to treat gastroesophageal reflux disease (GERD) and/or to decrease the acidity of the stomach to increase the effectiveness of PERT. Overall, proton pump inhibitors (PPIs) are prescribed more often (46.6 percent of individuals) than H2 blockers (17.9 percent of individuals). H2 blockers are used more frequently in younger individuals and their use tapers among older individuals. Use of PPIs increases with age until age 20 and then is prescribed to 51.9 percent of individuals age 20 and older.

In 2018, 91.1 percent of individuals age 2 to 19 and 79.8 percent of individuals age 20 and older were prescribed CF-specific vitamins, including vitamins A, D, E, and K. Additionally, 12.6 percent of individuals were prescribed ursodeoxycholic acid, which is most commonly prescribed to those with abnormal liver function tests or suspected CF liver disease.
Pulmonary Therapies

Chronic pulmonary therapies are a major component of the treatment regimen for individuals with CF. This section provides data on uptake and trends in the prescription of pulmonary medications recommended for chronic use by the CF Foundation pulmonary guidelines committee for individuals never transplanted. Data are also provided on medications that are not recommended and on those for which the committee did not find sufficient evidence to recommend for or against chronic use.⁴²

Many of the CF therapies are used by between 60 and 80 percent of the eligible population. The use of most therapies has increased over time. In recent years, additional formulations of inhaled tobramycin have become available, and they are included in the chart below. Dornase alfa, which is recommended for all individuals with CF, is used by the vast majority of people and its use continues to rise. Use of chronic inhaled antibiotics seems to have plateaued. The availability of multiple pulmonary therapies for CF is beneficial; however, this also contributes to treatment complexity and overall burden on individuals with CF and their caregivers.

![Medication Prescription in Eligible Individuals, 1998-2018](image)

*Tobramycin includes all available formulations of inhaled tobramycin. Dornase alfa, tobramycin solution for inhalation, and inhaled aztreonam were approved by the Food and Drug Administration in 1993, 1997, and 2010, respectively.*
**Pulmonary Medication Prescriptions by Age**

There are three classes of inhaled antibiotics for treatment of *P. aeruginosa* infections. Tobramycin is used most frequently, followed by aztreonam, and then colistin. For all medications, peak use occurs during adolescence and young adulthood.

Dornase alfa and hypertonic saline are each prescribed for the majority of individuals with CF. Azithromycin is also widely used, with peak use occurring at slightly older ages than for use of dornase alfa and hypertonic saline.

A substantial proportion of individuals with CF are prescribed inhaled corticosteroids and, to a lesser degree, leukotriene modifiers. Oral corticosteroids are used infrequently.
Bronchodilators are used extensively among individuals with CF. Almost all people with CF are prescribed beta agonists, except for a very small percentage who are prescribed anticholinergics. The vast majority of those prescribed beta agonists are on short-acting formulations.

Multiple pulmonary therapies are available for individuals with CF. Inhaled medications are effective treatments for pulmonary disease, and they require time to prepare, administer, and clean equipment after treatment. All people with CF are eligible for dornase alfa and hypertonic saline prescriptions. Those with *P. aeruginosa* infection or colonization are typically prescribed inhaled antibiotics. Almost all individuals are prescribed at least one inhaled medication, and about 80 percent of individuals aged 15 to 40 are prescribed two or more of these therapies.

Inhaled medication includes dornase alfa, hypertonic saline, and inhaled antibiotic. Inhaled antibiotic use includes the use of tobramycin, aztreonam, colistin, or other aminoglycosides.
Medications Recommended For Chronic Use

Recommended therapies are widely prescribed, with the exception of ibuprofen; however, there is considerable variation across the CF Foundation care center network. Increasingly, individuals with CF are using multiple inhaled antibiotics for the treatment of *P. aeruginosa* infections. CFTR modulators are discussed in a separate chapter (p. 57).

<table>
<thead>
<tr>
<th>Pulmonary Therapies Recommended for Chronic Use, by Center</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>------------------------------</td>
</tr>
<tr>
<td>Dornase Alfa Prescription in Individuals 6 Years and Older</td>
</tr>
<tr>
<td>Any Inhaled Tobramycin Prescription in <em>P. aeruginosa</em>-positive Individuals 6 Years and Older</td>
</tr>
<tr>
<td>Azithromycin Prescription in Eligible <em>P. aeruginosa</em>-positive Individuals 6 Years and Older*</td>
</tr>
<tr>
<td>Hypertonic Saline Prescription in Individuals 6 Years and Older</td>
</tr>
<tr>
<td>Ibuprofen Prescription in Individuals 6 to 17 Years with FEV(_1) Greater than 60 Percent Predicted</td>
</tr>
<tr>
<td>Inhaled Aztreonam Prescription in <em>P. aeruginosa</em>-positive Individuals 6 Years and Older</td>
</tr>
</tbody>
</table>

*Individuals were considered eligible if they met the selection criteria used in the U.S. trial of azithromycin in individuals chronically infected with *Pseudomonas aeruginosa*.*

Annual Data Report 2018  Cystic Fibrosis Foundation Patient Registry
Medications with Insufficient Evidence to Recommend for or Against Chronic Use

In 2013, the CF Foundation pulmonary guidelines committee determined that there was insufficient evidence to recommend for or against the chronic use of inhaled beta agonists, inhaled anticholinergics, inhaled colistin, leukotriene modifiers, and ibuprofen for adults to improve lung function, reduce exacerbations, or improve quality of life. Use of colistin has decreased in recent years. Inhaled beta agonists are used extensively, but the other medications are used infrequently. Adult use of ibuprofen is less than two percent.

<table>
<thead>
<tr>
<th>Pulmonary Therapies with Insufficient Evidence to Recommend For or Against Chronic Use, by Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Inhaled Beta Agonist Prescription in Individuals 2 Years and Older</td>
</tr>
<tr>
<td>Inhaled Anticholinergic Prescription in Individuals 2 Years and Older</td>
</tr>
<tr>
<td>Leukotriene Modifier Prescription in Individuals 2 Years and Older</td>
</tr>
<tr>
<td>Inhaled Colistin Prescription in Individuals 6 Years and Older with P. aeruginosa</td>
</tr>
</tbody>
</table>

Medications Not Recommended for Chronic Use

Inhaled steroids continue to be commonly prescribed, despite the recommendation against their chronic use in the absence of asthma or allergic bronchopulmonary aspergillosis (ABPA).

<table>
<thead>
<tr>
<th>Pulmonary Therapies Not Recommended for Chronic Use, by Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Inhaled Steroid Prescription in Individuals 6 Years and Older Without Asthma or ABPA</td>
</tr>
</tbody>
</table>
Medication Use in Young Children

The CF Foundation recently released the first set of guidelines focusing on the preschool timeframe from ages two to five. Although the results of rigorous efficacy trials are not available for this age group, the guidelines recommend that dornase alfa and hypertonic saline be selectively offered to these individuals on the basis of individual circumstances. The chart below shows the use of medications among children younger than age six.

<table>
<thead>
<tr>
<th>Medication Use in Individuals Under 6 Years, 2018</th>
<th>Age &lt; 3 Years (%)</th>
<th>Age 3 to 5 Years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Individuals (n)</td>
<td>1,877</td>
<td>2,272</td>
</tr>
<tr>
<td>Dornase alfa</td>
<td>42.5</td>
<td>72.2</td>
</tr>
<tr>
<td>Hypertonic saline</td>
<td>28.9</td>
<td>49.7</td>
</tr>
<tr>
<td>Inhaled bronchodilators</td>
<td>80.1</td>
<td>93.5</td>
</tr>
<tr>
<td>Inhaled corticosteroids</td>
<td>16.8</td>
<td>26.8</td>
</tr>
<tr>
<td>Inhaled tobramycin</td>
<td>18.5</td>
<td>22.1</td>
</tr>
<tr>
<td>Azithromycin</td>
<td>3.4</td>
<td>9.1</td>
</tr>
<tr>
<td>Inhaled aztreonam</td>
<td>1.0</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Airway Clearance Techniques

The CF Foundation pulmonary guidelines recommend airway clearance for all individuals with CF. A high-frequency chest wall oscillation (HFCWO) vest is the most widely used airway clearance technique in persons with CF after infancy.

The CF Foundation pulmonary guidelines recommend aerobic exercise as an adjunct therapy for airway clearance and for its additional benefits to overall health. Many individuals with CF report exercising in addition to their primary method of airway clearance, with 32.4 percent of children and 45.5 percent of adults identifying exercise as one of their methods of airway clearance.

Exercise as an Airway Clearance Technique (ACT) by Age in Years, 2018
CFTR Modulator Therapies

In 2018, eligibility for CFTR modulators increased, and by the end of the year, approximately 60 percent of individuals with CF were eligible. Specifically, ivacaftor eligibility was expanded to include infants age one year and older, lumacaftor/ivacaftor was expanded to include children age two years and older, and tezacaftor/ivacaftor received initial Food and Drug Administration approval for individuals age 12 years and older. Of those eligible, 68.5 percent of individuals were prescribed a CFTR modulator in 2018. Prescription rates differ across the population — 92.3 percent of individuals with G551D or other gating mutation were prescribed ivacaftor compared to 58.8 percent of individuals with an R117H mutation. Lumacaftor/ivacaftor was prescribed for 57.7 percent of eligible individuals (68.0 percent of those age 6 to 17 and 54.9 percent of those age 18 and older); a decrease from 2017, in part due to switching to tezacaftor/ivacaftor.

The above chart details the eligibility and prescribed use of CFTR modulators for all individuals in the 2018 Patient Registry data. Each vertical bar represents the CFTR modulator status of the patient population at the end of the calendar year. Using a colored flow chart, we show the migration of individuals from one status to another during a given year. This provides insight into which individuals are represented in each category at the end of the year. Starting at the end of 2011 (left-most vertical bar), all individuals were ineligible for CFTR modulators. In 2012, ivacaftor was approved for some, including an expansion for those age six years and older with a G551D mutation; many of them were prescribed the drug (shown in green). Additional individuals became eligible and many were
prescribed ivacaftor as the label expanded to other mutations and younger children. Those individuals eligible for a CFTR modulator, but not prescribed one, are shown in yellow. In 2015, the FDA approved lumacaftor/ivacaftor, shown in red. A significant proportion of eligible individuals were not prescribed the drug. It also appears that a significant number of individuals prescribed lumacaftor/ivacaftor discontinued it (see yellow strands that break off the red bar and rejoin the yellow bar). In 2018, the FDA approved tezacaftor/ivacaftor, shown in purple. Note the shift of many individuals from lumacaftor/ivacaftor to tezacaftor/ivacaftor. By the end of 2018, there were nearly as many individuals on tezacaftor/ivacaftor as lumacaftor/ivacaftor. Of the 4,486 individuals prescribed tezacaftor/ivacaftor in 2018, 38.1 percent were previously eligible but not prescribed a CFTR modulator, 54.6 percent were previously on lumacaftor/ivacaftor, and 7.3 percent were previously on ivacaftor. Also of note, approximately 40.4 percent of the patient population remained ineligible for a CFTR modulator, and 20.2 percent were eligible but not prescribed one of these therapies.

The number of individuals with CF who were prescribed a CFTR modulator in 2018 differs by age. Among adults, a large majority of those eligible were prescribed a modulator. Pediatric prescription rates are lower. The chart also highlights the number of individuals across all age groups for whom there is not yet an approved CFTR modulator.
Across all CF centers, at least two-thirds of eligible individuals are reported to have been prescribed CFTR modulators. Variability across centers remains with prescription rates ranging from a minimum of 33.3 percent to a maximum of 94.4 percent. Many factors affect the decision to prescribe a CFTR modulator including clinical indications, ability to access the medication, and individual preferences.

### Modulator Prescription in Eligible Individuals, by Center

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>100 Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible Individuals Prescribed a Modulator</td>
<td></td>
<td></td>
<td>67.7</td>
<td>33.3</td>
<td>94.4</td>
</tr>
<tr>
<td>Eligible Individuals Less than 18 Years Prescribed a Modulator</td>
<td></td>
<td></td>
<td>65.1</td>
<td>23.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Eligible Individuals 18 Years and Older Prescribed a Modulator</td>
<td></td>
<td></td>
<td>73.0</td>
<td>50.0</td>
<td>94.7</td>
</tr>
</tbody>
</table>
COMPLICATIONS

Management of complications secondary to CF is important for maintaining an individual’s health and quality of life. Complications of CF can affect many different organ systems; they can be the direct result of the malfunction or deficiency of the CFTR protein or a downstream effect of the disease or its treatment. The prevalence of some non-pulmonary CF complications is more common among individuals post-lung transplant than among individuals who have never had a lung transplant. As a result of removing individuals who had a lung transplant from the analyses, rates of some complications (e.g., CF-related diabetes (CFRD) and osteoporosis) are lower in 2018 than reported previously.

CFRD remains an important and highly prevalent complication that greatly impacts quality of life and is associated with increased morbidity and mortality. As the population ages, a larger proportion of individuals are reporting complications typically seen in older adults, including bone and joint disease and sinus disease. Furthermore, along with the recent publication and implementation of mental health screening guidelines, an increase in the reporting of anxiety and depression has been observed.

<table>
<thead>
<tr>
<th>Complications of CF, 2018</th>
<th>Age &lt; 18 (%)</th>
<th>Age ≥ 18 (%)</th>
<th>All (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Individuals (n)</td>
<td>13,918</td>
<td>15,136</td>
<td>29,054</td>
</tr>
<tr>
<td>Percent with no complications</td>
<td>25.1</td>
<td>4.6</td>
<td>14.5</td>
</tr>
<tr>
<td>Percent with complications not reported</td>
<td>1.4</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Cystic Fibrosis-Related Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cystic fibrosis-related diabetes (CFRD)</td>
<td>5.3</td>
<td>30.6</td>
<td>18.5</td>
</tr>
<tr>
<td>Hepatobiliary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gall stones</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Gall stones, requiring surgery/procedure</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Liver disease, cirrhosis</td>
<td>2.4</td>
<td>4.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Liver disease, non-cirrhosis</td>
<td>3.2</td>
<td>3.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Acute hepatitis</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Hepatic steatosis</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Liver disease, other</td>
<td>1.9</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Bone/Joints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arthritis/arthropathy</td>
<td>0.4</td>
<td>6.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Bone fracture</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Osteopenia</td>
<td>1.1</td>
<td>18.2</td>
<td>10.0</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>0.4</td>
<td>6.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Pulmonary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allergic bronchopulmonary aspergillosis (ABPA)</td>
<td>2.5</td>
<td>8.0</td>
<td>5.4</td>
</tr>
<tr>
<td>Asthma</td>
<td>29.3</td>
<td>33.5</td>
<td>31.5</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>0.7</td>
<td>5.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Hemoptysis, massive</td>
<td>&lt;0.1</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Pneumothorax requiring chest tube</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table continues on the next page
### Complications of CF, 2018 continued

<table>
<thead>
<tr>
<th>GI</th>
<th>Age &lt; 18 (%)</th>
<th>Age ≥ 18 (%)</th>
<th>All (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal intestinal obstruction syndrome (DIOS)</td>
<td>2.0</td>
<td>2.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Fibrosing colonopathy/colonic stricture</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Gastroesophageal reflux disease (GERD)</td>
<td>33.7</td>
<td>39.6</td>
<td>36.8</td>
</tr>
<tr>
<td>GI bleed requiring hospitalization (non-variceal)</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>History of intestinal or colon surgery</td>
<td>4.0</td>
<td>1.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>0.4</td>
<td>1.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Peptic ulcer disease</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Rectal prolapse</td>
<td>0.4</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Mental Health</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety disorder</td>
<td>4.6</td>
<td>21.8</td>
<td>13.5</td>
</tr>
<tr>
<td>Depression</td>
<td>3.4</td>
<td>27.2</td>
<td>15.8</td>
</tr>
<tr>
<td><strong>Other Complications</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer confirmed by histology</td>
<td>0.0</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Hearing loss</td>
<td>1.3</td>
<td>3.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.3</td>
<td>6.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Kidney stones</td>
<td>0.1</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Nasal polyps requiring surgery</td>
<td>1.5</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Renal failure requiring dialysis</td>
<td>&lt;0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Sinus disease</td>
<td>21.8</td>
<td>53.9</td>
<td>38.4</td>
</tr>
</tbody>
</table>

**A** Individuals for whom the complications case report form was not completed were considered to not have any complications, as in previous years.

**B** See table on page 66 for secondary complications.

**C** At the end of 2015, the data entry for complications was revised such that acute complications would no longer carry forward from one encounter to the next. We hypothesize that this is the reason for the decrease in the observed number of reported acute complications, most notably DIOS.

**D** See table below for secondary complications.

**E** Cause other than CFRD.

The table below highlights the prevalence of clinical manifestations of portal hypertension among individuals with cirrhosis.

### Complications of Cirrhosis, 2018 (n=935)

<table>
<thead>
<tr>
<th>Complication</th>
<th>All (%)</th>
<th>Age &lt; 18 (%)</th>
<th>Age ≥ 18 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Individuals (n)</strong></td>
<td>935</td>
<td>332</td>
<td>603</td>
</tr>
<tr>
<td>Esophageal varices</td>
<td>21.2</td>
<td>19.6</td>
<td>22.1</td>
</tr>
<tr>
<td>Gastric varices</td>
<td>4.1</td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td>GI bleed related to varices</td>
<td>2.0</td>
<td>1.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Splenomegaly</td>
<td>31.7</td>
<td>39.8</td>
<td>27.2</td>
</tr>
<tr>
<td>Hypersplenism</td>
<td>11.7</td>
<td>14.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Encephalopathy</td>
<td>0.7</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Ascites</td>
<td>4.4</td>
<td>2.4</td>
<td>5.5</td>
</tr>
</tbody>
</table>
CF Complications by Age, 2018

Reported complications differ in their distribution by age. Some are relatively stable over ages while others increase with age. The prevalence of bone disease and GERD is higher among older age groups. The prevalence of asthma peaks during adolescence and then decreases among adults while the prevalence of sinus disease and depression increases in adolescence and in young adults and then remains high through the older ages. The prevalence of CFRD is higher in adolescence and adulthood. ABPA and DIOS are less prevalent and appear across all age groups. Liver disease is more prevalent in children.
Cystic Fibrosis-Related Diabetes (CFRD)

CFRD is associated with weight loss, lung function decline, and increased mortality. Early diagnosis and treatment may minimize the impact of CFRD. The CF Foundation/American Diabetes Association clinical practice guidelines for CFRD recommend screening all individuals annually, starting at age 10, with an oral glucose tolerance test (OGTT).

Blood glucose testing is routinely performed at most CF care centers. The recommended OGTT is used less frequently, and substantial variation exists across CF care centers. It is encouraging to note that rates of screening adolescents for CFRD using the OGTT continues to increase since the CF Foundation clinical care guidelines for CFRD were published in 2010, whereas screening among adults lags behind.

### Percentage of Non-Diabetic Individuals Receiving Glucose Testing, by Center

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>100</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Glucose Measurements in Non-Diabetic Individuals 10 to 17 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any Glucose Measurements in Non-Diabetic Individuals 18 Years and Older</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OGTT Screening in Non-Diabetic Individuals 10 to 17 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OGTT Screening in Non-Diabetic Individuals 18 Years and Older</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Blood Glucose and OGTT Screening for Individuals without CFRD, 2001–2018

![Graph showing blood glucose and OGTT screening trends over 2001-2018](image-url)
Prevalence of CFRD is higher among adults as compared to children with CF. Impaired glucose tolerance is most prevalent in adolescence; these individuals are at increased risk for developing CFRD and may benefit from increased monitoring.

The vast majority of individuals who were diagnosed with CFRD are noted in the Registry as being treated with insulin, as recommended in the CF Foundation CFRD clinical care guidelines.45

**CFRD Treatment in 2018**

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Percent of People with CFRD on Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary change</td>
<td>20.0</td>
</tr>
<tr>
<td>Oral hypoglycemic agents</td>
<td>4.0</td>
</tr>
<tr>
<td>Intermittent insulin (with illness, steroids, etc.)</td>
<td>6.1</td>
</tr>
<tr>
<td>Chronic insulin</td>
<td>73.2</td>
</tr>
<tr>
<td>No treatment noted in reporting year</td>
<td>13.3</td>
</tr>
</tbody>
</table>

The data are not mutually exclusive and represent CFRD treatment at any point during the year.
The clinical practice guidelines recommend regular hemoglobin A1c (HbA1c) measurements for individuals with CFRD. Variation by CF care centers in the percentage of individuals with CFRD with one or more HbA1c measurements during the year shows that a majority of centers test their patients at least annually.

<table>
<thead>
<tr>
<th>Complications of CFRD in 2018</th>
<th>All (%)</th>
<th>Age &lt; 18 (%)</th>
<th>Age ≥ 18 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Individuals (n)</td>
<td>5,373</td>
<td>735</td>
<td>4,638</td>
</tr>
<tr>
<td>Retinopathy</td>
<td>0.8</td>
<td>0.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Microalbuminuria</td>
<td>1.3</td>
<td>0.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Chronic renal insufficiency</td>
<td>1.4</td>
<td>&lt;0.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Chronic renal failure requiring dialysis</td>
<td>0.1</td>
<td>&lt;0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Peripheral neuropathy</td>
<td>0.9</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Any episodes of severe hypoglycemia</td>
<td>5.2</td>
<td>3.4</td>
<td>5.5</td>
</tr>
</tbody>
</table>

The goal established by the CF Foundation guidelines for CFRD is an HbA1c less than 7.0 percent for individuals with CFRD. More than half of individuals with CFRD are meeting this guideline.

Rates of secondary complications of CFRD, including retinopathy, microalbuminuria, kidney disease, and neuropathy remain low. As the CF population continues to age, adult CF care providers should continue to screen individuals for these complications, as recommended by the CF Foundation clinical care guidelines for CFRD.
Depression and Anxiety

Addressing the mental health of all individuals with CF is critical to maintaining their overall health and quality of life. In 2015, the CF Foundation and the European CF Society published guidelines on screening and treatment for depression and anxiety among individuals with CF and caregivers of children with CF. These guidelines recommend annual screenings for all individuals with CF who are age 12 and older, as well as caregivers of children with CF.

There continues to be a steady increase in the number of adolescents and adults receiving a screening for depression or anxiety.

Of note, there is currently wide variation in screening across the CF care center network. Data on caregiver screening are not included in the Registry at this time.
Prevalence of both anxiety and depression increase through adolescence and early adulthood, then remain high at older ages. There is substantial overlap in individuals who report both anxiety and depression; among individuals who report anxiety or depression, 41.6 percent report both conditions.

![Depression and Anxiety by Age in Years, 2018](image-url)

The chart illustrates the number and percentage of individuals diagnosed with depression, anxiety, or both conditions across different age groups. The data shows a significant increase in the prevalence of both conditions from adolescence through early adulthood, with a sustained high prevalence in older age groups. The overlap between anxiety and depression is evident, with a notable 41.6% of individuals reporting both conditions.
TRANSPANTATION

Lung transplantation remains an option for some individuals with severe lung disease. The number of lung transplant procedures for individuals with CF fluctuates yearly, with an overall upward trend.

In 2018, there were 1,891 individuals in the Registry who were reported to have ever received a lung, kidney, heart, or liver transplant.

<table>
<thead>
<tr>
<th>Transplant Status of People with CF in 2018 (All Organs)</th>
<th>Number of Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepted, on waiting list</td>
<td>132</td>
</tr>
<tr>
<td>Evaluated, rejected</td>
<td>128</td>
</tr>
<tr>
<td>Received transplant this year</td>
<td>275</td>
</tr>
<tr>
<td>Received transplant in a prior year</td>
<td>1,616</td>
</tr>
</tbody>
</table>

Lung Transplantation

There were 1,715 post-lung transplant individuals in the Registry in 2018, including 253 individuals who were reported to have received a lung transplant in 2018. The number of CF lung transplants reported to the Registry is similar to the previous year, despite an overall modest increase in lung transplants in 2018 (2,530) compared to 2017 (2,449) as reported by the United Network for Organ Sharing. Overall, 6.3 percent of CF transplants performed in 2018 were among individuals younger than age 18.
Since 1991, there has been a steady increase in the number of lung transplants observed among individuals with CF. With improvements in survival, lung function, and BMI in the CF patient population, there was a sense that the age of transplant recipients would increase and there would be fewer pediatric transplants. Based on the data, that has not occurred to date. Specifically, between 2010 and 2018, the percentage of transplant recipients younger than age 18 remained stable (ranging from 4.0 percent to 10.0 percent during the time frame) and about 40 percent of transplants in both years occurred among individuals aged 18 to less than 30.

Overall, lung transplant recipients are a relatively small proportion of individuals included in the Registry; the majority are age 30 years and older.
While most CF care occurs within CF Foundation-accredited care centers, transplant and post-transplant care typically occurs at transplant centers. Therefore, some of these individuals are lost to follow-up in the Registry. Optimal care for CF transplant recipients should include periodic follow-up at a CF Foundation-accredited care center.

The last documented FEV₁ percent predicted prior to lung transplant demonstrates that the vast majority of individuals have FEV₁ percent predicted values less than 30 percent with almost half having FEV₁ percent predicted values less than 20 percent. The data underscore the severity of disease at the time of transplant and the potential benefit of earlier conversations about lung transplantation.
SURVIVAL

Over time, there have been substantial improvements in the survival of people with CF. We used a number of metrics to describe the survival of people living with CF in the United States. Definitions for these metrics are provided in the Technical Supplement that can be found on cff.org.

Median Predicted Survival

In 2018, the median predicted survival age of those born in 2018 was 47.4 years (95 percent confidence interval: 44.2–50.3 years). Given the instability of annual survival estimates due to the relatively low number of deaths in a given year, we group the data into five-year increments. The following graph shows gains in median predicted survival from 1987 to 2018 in five-year increments.* Between 2014 and 2018, the median predicted survival age was 44.4 years (95 percent confidence interval: 43.4–45.9 years). This means that half of individuals born from 2014 to 2018 are predicted to live beyond 44.4 years of age. This prediction assumes no further improvement in mortality rate and thus does not take into account the potential impact of CFTR modulators and other improvements in clinical care.

*Using the currently recommended method for calculating median predicted survival. For more information about the methodology, please see the Technical Supplement available at cff.org.
Median Conditional Predicted Survival

Median conditional predicted survival at specific ages is another metric to help understand changes in survival over time that considers an individual's current age. This metric reflects the population-based median for all individuals of a specific attained age and does not take individual characteristics into consideration. The figure ends at age 40 because the numbers at older ages are currently too small to accurately predict survival. As for median predicted survival, this metric assumes no further improvement in mortality rate.

Mortality Rate

The mortality rate in 2018 was 1.3 deaths per 100 individuals with CF in the Registry. There has been a steady decrease in the mortality rate over the last 30 years. This is encouraging, given that the median age of individuals in the Registry has increased from 11.5 years in 1988 to 19.8 years in 2018.
Median Age at Death

The median age at death was 30.8 years for the 410 people with CF who were reported to have died in 2018. About 13.9 percent of deaths occurred before 20 years of age. Comparing the cumulative percentage for age at death between 1988 and 2018 shows a substantial shift of the curve toward the right and a less steep curve, indicating that deaths are occurring at older ages and are spread across a wider age range. The median age at death reflects the reality of deaths in 2018 and cannot be used to predict survival of the entire population.

Causes of Death

Among the 410 deaths in 2018, the primary causes were respiratory/cardiorespiratory and organ transplant-related, similar to previous years. Of these, 46.1 percent of deaths occurred in people who were F508del homozygotes, reflecting their distribution in the Registry. While 5.7 percent of people in the Registry are post-transplant, 120 deaths (29.3 percent) occurred in transplant recipients. Note that the primary cause of death for these individuals was not always categorized as transplant-related.

<table>
<thead>
<tr>
<th>Primary Cause of Death in 2018</th>
<th>Number of Individuals</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory/cardiorespiratory</td>
<td>243</td>
<td>59.3</td>
</tr>
<tr>
<td>Transplant-related</td>
<td>70</td>
<td>17.1</td>
</tr>
<tr>
<td>Other</td>
<td>27</td>
<td>12.4</td>
</tr>
<tr>
<td>Unknown</td>
<td>24</td>
<td>5.9</td>
</tr>
<tr>
<td>Liver Disease/Liver Failure</td>
<td>14</td>
<td>3.4</td>
</tr>
<tr>
<td>Suicide or Drug Overdose</td>
<td>8</td>
<td>2.0</td>
</tr>
</tbody>
</table>
# 2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

## DEMOGRAPHIC DATA

**Demographics**

- **CFF Patient Number:** ______________________
- **Last Name:** ______________________________
- **Last Name at Birth (if different):** ______________
- **First Name:** _____________________________
- **Middle Name:** ____________________________
- **Last 4 digits of SSN:** _______________________
- **Date of Birth:** (MM/DD/YYYY)
- **State of Birth:**  ____________________________
- **Gender:**
  - [ ] Male  [ ] Female
- **Current Zip:** ______________________________
- **Is patient residing in the US permanently?**
  - [ ] Yes  [ ] No  [ ] Unknown
- **Emergency Phone:** ________________________
- **Email:** ___________________________________

### Race/Ethnicity Information

- **Race:**
  - [ ] White  [ ] Black or African American  [ ] American Indian or Alaska Native  [ ] Asian  [ ] Native Hawaiian or Other Pacific Islander  [ ] Some other race
  - If two or more races, specify Mixed Race components:
    - [ ] White  [ ] Black or African American  [ ] American Indian or Alaska Native  [ ] Asian  [ ] Native Hawaiian or Other Pacific Islander
- **Is the Patient of Hispanic Origin?**
  - [ ] Yes  [ ] No  [ ] Unknown

## CF DIAGNOSIS

### History of patient diagnosis*

- **Date of Diagnosis:** (MM/DD/YYYY)
- **Date is an approximation:** [ ]

### Diagnosis:

- [ ] Cystic Fibrosis
- [ ] CFTR-related metabolic syndrome
- [ ] CFTR-related disorder
- [ ] CF, CRMS and CFTR-related disorder all ruled out

### Patient was diagnosed with CF after false negative result by newborn screening:

- [ ] Yes  [ ] No  [ ] Unknown

### Diagnosis Suggested by the following:

- [ ] Acute or persistent respiratory abnormalities
- [ ] CBAVD (absent vas deferens) or related abnormalities
- [ ] Digital clubbing
- [ ] DNA Analysis
- [ ] Edema
- [ ] Electrolyte imbalance
- [ ] Elevated immunoreactive trypsinogen (IRT) at CF newborn screening
- [ ] Failure to thrive/malnutrition
- [ ] Family history
- [ ] Infertility/GU abnormalities
- [ ] Less than 2 identified disease causing mutations
- [ ] Liver problems
- [ ] Meconium ileus/other intestinal obstruction (provide details below)
  - meconium ileus with perforation
  - meconium ileus without perforation
- [ ] Other neonatal bowel obstruction: ____________________________
- [ ] Nasal polyps/sinus disease
- [ ] Newborn (neonatal) screening
- [ ] Non-diagnostic sweat chloride value (<60 mmol/L)
- [ ] Pancreatitis (not explained by other etiologies)
- [ ] Persistent respiratory colonization/infection with a typical CF pathogen(s) (e.g., Pseudomonas aeruginosa)
- [ ] Prenatal screening (CVS, amnio)
- [ ] Pulmonary mycobacterial infection
- [ ] Rectal prolapsed
- [ ] Repeat Normal Sweat Testing
- [ ] Steatorrhea/abnormal stools/malabsorption
- [ ] Transepithelial potential differences
- [ ] Other, specify: ____________________________
- [ ] Unknown

### Date & value of documented positive quantitative pilocarpine iontophoresis sweat test (Chloride)*

- **Date of Test:** MM/DD/YY
- **Value (mmol/L):** ____________________________

### Quantity Not Sufficient:

- [ ]

### If sweat test value <=60, CF diagnosis was suggested by:

- [ ] DNA Analysis/genotyping
- [ ] Transepithelial potential differences
- [ ] Clinical presentation (pancreatic fxn tests, Microbiology, etc.)
- [ ] Unknown

---

**Key:**

- [ ] radio buttons (select one option only)
- [ ] check box (multiple selections allowed)

---

*repeated entries can be recorded

[ ] indicates values calculated by the registry
2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

Parents’ Information (information not required for patients 21 years of age and older)
Not available: □
Mother height: _____ cm □ inches
Father height: _____ cm □ inches

Birth Measurements
Baby delivered:
○ Full term (≥ 37 weeks gestational age)
○ Premature (< 37 weeks gestational age)
○ Unknown

Specify gestational age (only if premature):______
Birth length: _____ cm □ inches
Birth weight:____ kg □ lb

Genotype Information
For a list of mutation options, please contact reghelp@cff.org
Has this patient been genotyped?  ___ Yes     ___ No

Select Mutation 1: ________  Other genotype: ___________
Poly T tract: □ 5T □ 7T □ 9T □ not 5T □ Unknown
Poly TG repeats: □ 9 □ 10 □ 11 □ 12 □ 13
○ Other/unknown/not done

Select Mutation 2: ________ Other genotype: ___________
Poly T tract: □ 5T □ 7T □ 9T □ not 5T □ Unknown
Poly TG repeats: □ 9 □ 10 □ 11 □ 12 □ 13
○ Other/unknown/not done

Select Mutation 3: ________ Other genotype: ___________

Additional information about genotype not captured above:
__________________________________________________

ENCOUNTER DATA
Vital Signs/Encounter Start
Encounter date: (MM/DD/YYYY)
Location: □ Clinic □ Hospital □ Home IV □ Other
Height : _____ cm □ inches
[Height Percentile ______ ]
Weight : _____ kg □ lb
[Weight Percentile ______ ]
[BMI value: __________ ]
[BMI Percentile: __________ ]
[Weight for Length percentile: __________ ]

Exacerbation Assessment
Were there crackles (rales) on physical exam at this visit?
○ Yes    □ No    □ Physical exam data not available

What was your assessment regarding pulmonary exacerbation at this visit?
○ Absent    □ Mild exacerbation    □ Moderate exacerbation

Key:
□ radio buttons (select one option only)
□ check box (multiple selections allowed)

If you determined that an exacerbation was present, please select the treatment course prescribed to treat the exacerbation:
□ Increased airway clearance, exercise, and/or bronchodilators
□ Oral NON-quinolone antibiotic (e.g. azithromycin, Bactrim, Augmentin, etc.)
□ Oral quinolone antibiotic (e.g. ciprofloxacin (Cipro), levofloxacin)
□ Inhaled antibiotic
□ Inhaled antibiotic PLUS Oral NON-quinolone antibiotic
□ Inhaled antibiotic PLUS an oral quinolone antibiotic
□ None of the above

If none of the above, the specify:____________________
(Note: If you elected to treat with hospital or home IV antibiotics, please start a care episode and enter the requested data.)

Consultations with Care Team Members
□ Patient consulted with a Social Worker at this visit
□ Patient was seen by a Dietitian/Nutritionist at this visit
□ Patient was seen by a Physical therapist at this visit
□ Patient was seen by a Respiratory therapist at this visit
□ Patient consulted with a Pharmacist at this visit
□ Patient was seen by a Mental Health Coordinator at this visit

Other
Record any additional information about this encounter:
Custom field 1: ___________________________________
Custom field 2: ___________________________________
Custom field 3: _________________________________

Microbiology
Bacterial Culture
Bacterial culture done? □
Date of Culture: (MM/DD/YYYY)
Type of Specimen:
□ sputum    □ induced sputum
□ throat/nasal    □ bronchoscopy

Culture Results:
□ Microorganisms    □ Normal flora
□ No growth/sterile culture

Staphylococcus aureus: □
□ MRSA (methicillin resistant Staph aureus)
□ MSSA (methicillin sensitive Staph aureus)

Haemophilus influenzae (any species): □
Pseudomonas aeruginosa: □
□ mucoid    □ non mucoid    □ mucoid status unknown

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### 2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

**Susceptibility Testing** *(Please use the most resistant PA strain. If multiple PA strains are resistant to the same number of classes of antibiotics then use the following schema: Beta lactams> Quinolones> Aminoglycosides).*

Resistant to All Aminoglycosides Tested *(e.g., tobramycin, gentamicin, amikacin):*
- ☐ Yes
- ☐ No
- ☐ Testing not done

Resistant to All Quinolones Tested *(e.g., ciprofloxacin, levofloxacin, moxifloxacin):*
- ☐ Yes
- ☐ No
- ☐ Testing not done

Resistant to All Beta Lactams Tested *(e.g., ceftazidime, imipenem, meropenem, piperacillin/tazobactam (Zosyn), ticarcillin/clavulanic acid (Timentin), aztreonam):*
- ☐ Yes
- ☐ No
- ☐ Testing not done

**Other resistant microorganisms:**
- ☐ Burkholderia species:
  - ☐ B. gladioli
  - ☐ B. cenocepacia
  - ☐ B. multivorans
  - ☐ Burkholderia – other
    - ☐ B. cepacia
    - ☐ B. stabilis
    - ☐ B. vietnamiensis
    - ☐ B. dolosa
    - ☐ B. anhila
    - ☐ B. ambifaria
    - ☐ B. pyroccinia
    - ☐ B. ubonensis
    - ☐ B. arboris
    - ☐ B. latens
    - ☐ B. lata
    - ☐ B. metallica
    - ☐ B. seminalis
    - ☐ B. contaminans
    - ☐ B. diffusa
    - ☐ B. pseudomallei

Was the identification of the Burkholderia species confirmed at the CFF reference lab? *
- ☐ Yes
- ☐ No
- ☐ Unknown

**Other microorganisms:**
- ☐ Alcaligenes (Achromobacter) xylosoxidans
- ☐ Stenotrophomonas (Xanthomonas)/Maltophilia
- ☐ Other types:
  - ☐ Acinetobacter baumannii
  - ☐ Agrobacterium species
  - ☐ Brevundimonas species
  - ☐ Cupriavidus metallidurans
  - ☐ Cupriavidus pauculus
  - ☐ Delfla species - other*
  - ☐ Exophila dermatitidis
  - ☐ Herbaspirillum seropedicale
  - ☐ Klebsiella pneumoniae
  - ☐ Ochrobacterium species
  - ☐ Pandorea species
  - ☐ Pandorea sputorum
  - ☐ Pseudomonas mendocina
  - ☐ Pseudomonas pseudalcaligenes
  - ☐ Pseudomonas putida
  - ☐ Pseudomonas species - other*
  - ☐Ralstonia insidiosa
  - ☐ Ralstonia pickettii
  - ☐ Streptococcus milleri

**Fungal/Yeast:**
- ☐ Aspergillus (any species)
- ☐ Candida (any species)
- ☐ Scedosporium species

**Other bacterial or fungal species:** ☐
Specify: __________________

**Mycobacterial culture**
- Was Mycobacterial culture done? ☐
- Date of Culture: (MM/DD/YYYY)
- Type of Specimen:
  - ☐ sputum
  - ☐ induced sputum
  - ☐ bronchoscopy
- AFB Smear:
  - ☐ Positive
  - ☐ Negative
  - ☐ Not done
- Culture Results:
  - ☐ Microorganisms
  - ☐ Normal flora
  - ☐ No growth/sterile culture

**Mycobacterial Species:**
- ☐ Mycobacterial tuberculosis
- ☐ Mycobacterium abscessus/chelonae
- ☐ Mycobacterium avium complex (MAC)
- ☐ Mycobacterium fortuitum group
- ☐ Mycobacterium gordonea
- ☐ Mycobacterium kansasii
- ☐ Mycobacterium marinum
- ☐ Mycobacterium terrae
- ☐ Other
  - Specify: __________________

Please note: The option *Mycobacterium avium complex (MAC)* includes *M. avium subsp. Avium, M. avium subsp. Hominis/aus, M. avium subparatuberculosis, and M. intracellulare.*

**Medications**

**Not on Medications**
- This patient is not on any of the pulmonary medications below: ☐

**Pulmonary Medications**

**Antibiotics – inhaled and/or oral**

**Tobramycin Based Medications**

- Tobramycin solution for inhalation (i.e. TOBI): ☐
  - Frequency: ☐ 300 mg BID alternate month schedule
  - ☐ 300 mg BID continuous
  - ☐ Other regimen (different dose or freq)
  - ☐ Eradication

- Tobi Podhaler (Tobramycin Inhalation Powder): ☐
  - Frequency: ☐ Four 28mg capsules BID alternate month
  - ☐ Other regimen (different dose or freq)
  - ☐ Eradication

- Bethkis: ☐
  - Frequency: ☐ 300 mg BID alternate month
  - ☐ Other regimen (different dose or freq)
  - ☐ Eradication

**Other inhaled aminoglycoside (e.g. gentamicin, amikacin, or tobramycin preparation): ☐**
- Frequency: ☐ Alternate Month

---

*repeated entries can be recorded

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### 2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

**Key:**
- ○ radio buttons (select one option only)
- □ check box (multiple selections allowed)

**Colistin:** □
**Frequency:**
- ○ Alternate Month
- ○ Continuous
- ○ Other regimen (different dose or frequency)
- ○ Eradication

**Aztreonam – Inhaled:** □
**Frequency:**
- ○ 75 mg TID Alternate Month Schedule
- ○ 75 mg TID Continuous
- ○ Other Regimen
- ○ Eradication

**Other inhaled antibiotics:** □
**Comments:** ____________________________

**Oral macrolide antibiotic:** □
- □ azithromycin (Zithromax)
- □ clarithromycin (Biaxin)

**Other oral antibiotic:** □
- □ Quinolone (Cipro, Levaquin, gatifloxacin, etc.)
- □ Cephalosporin (cephalexin, Keflex, cefixime, etc.)
- □ Sulfamethoxazole/Trimethoprim (Septra, Bactrim, etc.)
- □ Amoxicillin (Augmentin, etc.)
- □ Tetracycline (doxycycline, Vibramycin, minocycline, etc.)
- □ Other

**CFTR Modulators**
- **Ivacaftor Monotherapy (i.e. Kalydeco):** □
  **Frequency:**
  - ○ 50 mg BID
  - ○ 75 mg BID
  - ○ 150 mg BID
  - ○ Other Regimen (different dose or freq)

- **Ivacaftor/Lumacaftor Combination Therapy (i.e. Orkambi):** □
  **Frequency:**
  - ○ Full dose BID
  - ○ Half dose BID
  - ○ Other Regimen (different dose or freq)

- **Tezacaftor/Ivacaftor Combination Therapy:** □
  **Frequency:**
  - ○ Full dose BID
  - ○ Half dose BID
  - ○ Other Regimen (different dose or freq)

**Other Medications**
- **Dornase alfa (i.e. Pulmozyme):** □
  **Frequency:**
  - ○ 2.5 mg QD
  - ○ 2.5 mg BID
  - ○ Other regimen (different dose or frequency)

- **Acetylcysteine or Mucomyst:** □
  **High-dose ibuprofen (e.g. 25-30 mg/kg):** □
  **Total (mg/dose):** ______

**Corticosteroids:**
- □ Oral (e.g. prednisone)
- □ Inhaled (e.g. fluticasone, Flovent, budesonide, Pulmicort, etc.)
- □ Inhaled in combination with a bronchodilator (e.g. Advair, Symbicort)

**Other:**
- □ Leukotriene modifiers (e.g. montelukast, Singular, zafirlukast, Accolate, zileuton, Zyflo, etc.)
- □ Mast cell stabilizers (e.g. cromolyn, Intal, nedocromil, Tilde, etc.)
- □ Antifungals (e.g. itraconazole, Sporanox) Note: exclude topical agents for skin conditions and agents used for oral thrush)

**Drug Intolerance/Allergies:**
- □ Dornase alfa (i.e. Pulmozyme)
- □ TOBI or other aminoglycoside
- □ Aztreonam
- □ Colistin
- □ Macrolide antibiotics
- □ High-dose ibuprofen
- □ Hypertonic saline
- □ Ivacaftor (i.e. Kalydeco)
- □ Ivacaftor Lumacaftor (i.e. Orkambi)
- □ Tezacaftor/Ivacaftor (i.e. Symdeko)

**GI/Nutrition/Endocrine Medications**
This Patient is on enzyme medications: □ Yes □ No

For all enzymes, "capsules per largest meal" options are:
- ○ .5
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10
- ○ 10+

*Total capsules per day* is a numeric free text field.

**Enzymes**
- **Creon**
  Creon 1203: □
  - Number of capsules per largest meal of the day:____
  - Total capsules per day:_____  
  Creon 1206: □
  - Number of capsules per largest meal of the day:____

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## 2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

<table>
<thead>
<tr>
<th>Enzyme Type</th>
<th>Enzyme Name</th>
<th>Number of capsules per largest meal of the day:</th>
<th>Total capsules per day:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creon 1212:</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creon 1224:</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creon 1236:</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pancreaze MT4:</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pancreaze MT10:</td>
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</tr>
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<td>Zenpep 3:</td>
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<td></td>
<td>Viokace 10:</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Other Enzymes:</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Acid Blocker:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GI other:</td>
<td>Ursodeoxycholic acid:</td>
<td>□</td>
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<tr>
<td></td>
<td>Pulmonary Function Tests (PFTs):</td>
<td>Unable to Perform test:</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>FVC measure (L):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FEV1 measure (L):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FEF25-75 measure (L/sec):</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Key:
- □ radio buttons (select one option only)
- □ check box (multiple selections allowed)

*repeated entries can be recorded

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### 2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

#### Key:
- Radio buttons (select one option only)
- Check box (multiple selections allowed)

#### GI/Nutrition

**Assessment of Oral Intake:**
- ☐ Done
- ☐ Not done

**Is patient currently receiving supplemental feeding?**
- ☐ Yes
- ☐ No
- ☐ Unknown

**Feeding:**
- ☐ oral supplementation (Scandishakes, Pediasure, Instant Breakfast, etc.)
- ☐ nasogastric tube (NG)
- ☐ gastrostomy tube/button (G-Tube)
- ☐ jejunal tube (J-tube)
- ☐ total parenteral nutrition (TPN)

If using a tube (NG, G-tube or J-tube), was the patient recommended to use pancreatic enzymes with supplemental feedings?
- ☐ No enzymes recommended with tube feeding
- ☐ Yes enzymes mixed into the formula
- ☐ Yes, enzymes administered directly through the tube (i.e., not into the formula)
- ☐ Yes, enzymes taken by mouth prior to, during and/or after the feeding
- ☐ Yes, formula infused through Relizorb (enzyme cartridge)
- ☐ Other

**CF specific vitamins (i.e., with additional vitamins A, D, E, and K):**
- ☐ Yes
- ☐ No

#### Infants under 2 years of age

**Salt supplementation:**
- ☐ Yes
- ☐ No

**Select type of feeding:**
- ☐ Breast milk
- ☐ Breast milk plus formula
- ☐ Formula exclusively
- ☐ Other food
- ☐ Unknown

If receiving any formula feeding, select type of formula and caloric density:
- ☐ Cow's milk
- ☐ Soy milk
- ☐ Predigested
- ☐ Other

**Caloric Density:**
- ☐ 20 cal/oz
- ☐ 22 cal/oz
- ☐ 24 cal/oz
- ☐ 27 cal/oz
- ☐ 30 cal/oz
- ☐ Other, specify: ____________

#### Complications

**Patient does not have any complications:** ☐

**Diabetes Status**
- ☐ Impaired Glucose Tolerance (FBG < 126, 2-h PG 140-199)
- ☐ CFRD with or without fasting hyperglycemia
- ☐ Type 1 Diabetes
- ☐ Type 2 Diabetes

**CFRD secondary complications:**
- ☐ Retinopathy

**Hepatobiliary**
- ☐ Gall stones
- ☐ Gall stones, requiring surgery/procedure
- ☐ Liver disease, cirrhosis
  - Please specify complications related to cirrhosis:
    - ☐ Esophageal varices
    - ☐ Gastric varices
    - ☐ GI bleed related to varices
    - ☐ Splenomegaly
    - ☐ Hypersplenism (i.e., WBC <3.0 or platelets <100,000)
    - ☐ Ascites
    - ☐ Encephalopathy
- ☐ Liver disease, non-cirrhosis
- ☐ Acute Liver Failure (No underlying liver disease, ALT>3X ULN, INR>2, not responsive to vitamin K)
- ☐ Hepatic Steatosis
- ☐ Liver disease, other: ____________

**Acute Hepatitis (ALT > 5X ULN and duration of illness < 6 months):**
- ☐ Infectious (Hepatitis A,B,C,EBV,CMV or other known infectious cause)
- ☐ Non-infectious (Autoimmune, Drug Induced, Alcohol or other known cause)
- ☐ Unknown

**Bone/Joints**
- ☐ Arthritis/Arthropathy
- ☐ Bone fracture
- ☐ Osteopenia
- ☐ Osteoporosis

**Pulmonary**
- ☐ Allergic Bronchial Pulmonary Aspergillosis (ABPA)
- ☐ Asthma
- ☐ Hemoptysis
  - Please specify selection of hemoptysis:
    - ☐ Hemoptysis, massive
    - ☐ Hemoptysis, other
- ☐ Pneumothorax requiring chest tube

**GI**
- ☐ Distal intestinal obstruction syndrome (DIOS, Meconium ileus equiv.)
- ☐ Fibrosing colonopathy/colonic stricture (report incidence only)
- ☐ GERD (Gastro-Esophageal Reflux Disease)
- ☐ GI Bleed req hosp non variceal
- ☐ History of intestinal or colon surgery
- ☐ Pancreatitis
- ☐ Peptic ulcer disease
- ☐ Rectal prolapse

**Other Complications**
- ☐ Microalbuminuria
- ☐ Chronic renal insufficiency
- ☐ Chronic renal failure requiring dialysis
- ☐ Peripheral neuropathy

*repeated entries can be recorded
[ ] indicates values calculated by the registry
### Complications not listed above
Enter additional complications: ______________________

### Lab
**Blood counts**
- WBC count x1,000/microL (typical clinical value: 3.0 to 30.0): _____
- Platelet Count x1,000/microL (typical clinical value: 100 to 500): _____
- Hemoglobin (grams per deciliter): _____

**Serum Creatinine**
- Serum Creatinine Level (mg/dL): _____

**Liver Function Tests (LFTs)**
- Alanine Aminotransferase (ALT or SGPT), IU/L: _____
- GGTP (gamma glutamyl transpeptidase), IU/L: _____
- Aspartate Aminotransferase (AST), IU/L: _____
- Alkaline phosphatase (ALP), IU/L: _____
- Total Bilirubin, mg/dL: _____

**Glucose Test**
- Random blood glucose (mg/dL): _____
- Fasting blood glucose (mg/dL): _____

*If OGTT performed:*
- OGTT Fasting glucose level (mg/dL): _____
  - 1 hour (mg/dL) (not required): _____
  - 2 hour (mg/dL): _____

**Hemoglobin A1C (Hgb A1C)**
- Hgb A1C value, %: _____

**Fecal Elastase**
- Fecal Elastase Value (microg/g of stool): _____

### Act/Exercise
**Primary Airway Clearance Technique (ACT)**
- Positive Expiratory Pressure (PEP)
- Postural drainage with clapping (CPT)
- Forced expiratory techniques (e.g. autogenic drainage, huff cough, active cycle breathing)
- Oscillating PEP (e.g. Flutter, acapella, IPV)
- High frequency chest wall oscillation (e.g. Vest)
- Exercise
- None

### CARE EPISODE
**Care Episode Segment**
- Start date: (MM/DD/YYYY)
- End date: (MM/DD/YYYY)
- Location:  
  - Hospital
  - Home IV
- Reasons:
  - Pulmonary Exacerbation
  - Pulmonary Complication Other than exacerbation
  - GI Complications
  - Transplant related
  - Sinus infection
  - Non-transplant surgery
  - NTM Pulmonary Infection
  - Other
  - Please specify reason: ______________

### Care Episode Measurements
*At the beginning of Care Episode:*
- FVC (L): _____
- FEV1 (L): _____
- FEF25-75 (L): _____
- Height:  _____  
  - cm
  - inches
- Weight:  _____
  - kg
  - lb
- Date recorded: (MM/DD/YYYY)

*Check if data were impossible to measure: ☐

*At the end of Care Episode:*
- FVC (L): _____
- FEV1 (L): _____
- FEF25-75 (L): _____
- Height:  _____
  - cm
  - inches
- Weight:  _____
  - kg
  - lb
- Date recorded: (MM/DD/YYYY)

*Check if data were impossible to measure: ☐

### Comments: __________________________

### ANNUAL REVIEW
**Annual Review Year:** (YYYY)

### Patient Statistics
**Number of Encounters recorded by Center:** [ ]
**Number of Encounters recorded by other Care Centers:** [ ]
**Number of Care Episodes recorded by Care Center:** [ ]

*repeated entries can be recorded
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### Pulmonary
- Did this patient use oxygen therapy during the reporting year?
  - Yes, Continuously
  - Yes, Nocturnal and/or with exertion
  - Yes, During exacerbation
  - Yes, prn
  - No
  - Unknown

- Did this patient use non-invasive ventilation during the reporting year (i.e., assisted breathing, BiPap, CPAP, etc)?
  - Yes
  - No
  - Unknown

- Was a Chest X Ray performed during the reporting year?
  - Yes
  - No
  - Unknown

- Did the patient receive an influenza vaccination this season (Sept through Jan)?
  - Yes
  - No
  - Unknown

### Mycobacterial Culture
- [According to the encounters a Mycobacterial culture has been performed during this reporting year:]
  - Yes
  - No

  Please check to confirm the above is correct: □

- Was treatment INITIATED for a pulmonary mycobacterial infection during this reporting year?
  - Yes
  - No
  - Unknown

- Was an IgE screening for ABPA performed in this reporting year?
  - Yes
  - No
  - Unknown

### Growth and Nutrition
- Fat soluble vitamin levels measured?
  - Yes
  - No
  - Unknown

- Has this patient been on growth hormone in the reporting year?
  - Yes
  - No
  - Unknown

- Was a DEXA scan for bone density performed in the reporting year? Please enter findings of osteoporosis or osteopenia into the complications section of last patient encounter.
  - Yes
  - No
  - Unknown

  - Normal
  - Osteopenia
  - Osteoporosis
  - Other
  - Unknown

### Diabetes Status
- Status from recent encounter [does or does not] indicate CFRD.
  - Normal Glucose Metabolism (includes normal, random, fasting, or OGGT)
  - Impaired Glucose Tolerance (FBG < 126, 2-h PG 140-199)
  - CFRD with or without fasting hyperglycemia (2-h PG >= 200)
  - Type 1 Diabetes
  - Type 2 Diabetes

- Was a retinal eye exam performed by an ophthalmologist in this reporting year?
  - Yes
  - No
  - Unknown

- Was a spot urine sent for albumin/creatinine ratio in this reporting year?
  - Yes
  - No
  - Unknown

- Was the patient prescribed treatment for CFRD?
  - Yes
  - No

Select all that apply:
- □ Dietary change
- □ Oral hypoglycemic agents
- □ Intermittent insulin (with illness, steroids, etc.)
- □ Chronic insulin

- Did the patient experience any episodes of severe hypoglycemia (became unconscious or required help to resolve) during the reporting year?
  - Yes
  - No
  - Unknown

### Transplantation
- What is the transplantation status of the patient currently? If the patient had transplantation in previous years please select or keep "Had transplantation" option.
  - Not pertinent
  - Accepted, on waiting list
  - Evaluated, final decision pending
  - Evaluated, rejected

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2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

- Had transplantation
  - Transplant
    - Lung: Bilateral
      - Number this year: ___ Date of last transplant: (MM/DD/YYYY)
    - Heart/Lung
      - Number this year: ___ Date of last transplant: (MM/DD/YYYY)
    - Lung: Lobar/Cadaveric
      - Number this year: ___ Date of last transplant: (MM/DD/YYYY)
    - Lung: Lobar/living donor
      - Number this year: ___ Date of last transplant: (MM/DD/YYYY)
    - Other
      - Number this year: ___ Date of last transplant: (MM/DD/YYYY)

  Specify transplant type: _____

- Were there post transplant complications? □
  Select those that apply:
    - Bronchiolitis obliterans syndrome
    - Lympho-proliferative disorder
    - Other
      - Specify other complication: ________________________

- Colorectal Cancer Screening/Surveillance
  Did the patient undergo a colonoscopy (screening or surveillance during the reporting year?)
  - Yes  ○ No  ○ Unknown
  What were the results of the colonoscopy?
    - Normal
    - Colorectal Cancer
    - Adenomatous polyps
    - Indeterminate results (e.g. inadequate preparation)

- Clinical Trials
  Has this patient participated in any interventional (drug) studies?
  - Yes  ○ No  ○ Unknown

  Has this patient participated in any observational studies?
  - Yes  ○ No  ○ Unknown

- Health Insurance Coverage
  It is important for us to have accurate numbers of patients who have specific types of coverage:
  - Health Insurance Policy (e.g. Private Insurance)
  - Medicare
  - Medicaid
  - State special needs program, e.g., BCMH, CCS, CRS, GHP, etc.
  - TriCare or other military health plan
  - Indian Health Service
  - Other
    - Specify if other insurance: ________________________

  Patient has no health insurance: □

Key:
- FORM NAME
  ○ radio buttons (select one option only)
  □ check box (multiple selections allowed)

  *repeated entries can be recorded
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2018 Cystic Fibrosis Foundation Patient Registry Questionnaire

Was the patient screened for the anxiety disorder using Generalized Anxiety Disorder Tool (GAD-7 or similar)?
- Yes
- No
- Unknown

Age 18 and Older
Marital Status:
- Single (never married)
- Living Together
- Married
- Separated
- Divorced
- Widow
- Unknown

Employment:
- Part Time
- Full time homemaker
- Full time employment
- Unemployed
- Student
- Disabled
- Retired
- Unknown

Pregnancy
Was patient pregnant during the reporting year?
- Yes
- No
- Unknown

If Yes, indicate outcome:
- Live Birth
- Still Birth
- Spontaneous Abortion
- Therapeutic Abortion
- Undelivered
- Unknown

Age 2 and Younger
Did the patient attend day care during this reporting year?
- Yes
- No
- Unknown

Did the family receive genetic counseling this reporting year?
- Yes
- No
- Unknown

Was the patient given palivizumab (Synagis) this season (Sept through January)?
- Yes
- No
- Unknown

Other
Please use this field to record any additional information about this patient: _______________________________
REFERENCES
