

1 **Evaluating Specimen Quality and Results from a Community-Wide, Home-Based Respiratory**  
2 **Surveillance Study**

3

4 **Running Title:** Evaluating Home-Based Respiratory Surveillance

5

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29 preparedness

30

31 **Abstract**

32

33 **Introduction.** While influenza and other respiratory pathogens cause significant morbidity and  
34 mortality, the community-based burden of these infections remains incompletely understood.

35 The development of novel methods to detect respiratory infections is essential for mitigating  
36 epidemics and developing pandemic-preparedness infrastructure.

37

38 **Methods.** From October 2019 to March 2020, we conducted a home-based cross-sectional  
39 study in the greater Seattle area, utilizing electronic consent and data collection instruments.

40 Participants received nasal swab collection kits via rapid delivery within 24 hours of self-  
41 reporting respiratory symptoms. Samples were returned to the laboratory and were screened  
42 for 26 respiratory pathogens and a human marker. Participant data were recorded via online  
43 survey at the time of sample collection and one week later.

44

45 **Results.** Of the 4,572 consented participants, 4,359 (95.3%) received a home swab kit, and  
46 3,648 (83.7%) returned a nasal specimen for respiratory pathogen screening. The 3,638 testable  
47 samples had a mean RNase P C<sub>R</sub>T value of 19.0 (SD: 3.4) and 1,232 (33.9%) samples had positive  
48 results for one or more pathogens, including 645 (17.7%) influenza-positive specimens. Among  
49 the testable samples, the median time between shipment of the home swab kit and completion  
50 of laboratory testing was 8 days [IQR: 7.0-14.0].

51

52 **Discussion.** Home-based surveillance using online participant enrollment and specimen self-  
53 collection is a feasible method for community-level monitoring of influenza and other  
54 respiratory pathogens, which can readily be adapted for use during pandemics.

55

## 56 **Introduction**

57

58 Acute respiratory illnesses (ARIs) constitute a significant burden on the healthcare system in the  
59 United States and represent an important cause of morbidity and mortality worldwide [1-4]. In  
60 the United States, influenza causes 140,000 - 810,000 hospitalizations and 12,000 - 67,000  
61 deaths annually [1-4]. Additionally, respiratory syncytial virus (RSV) leads to approximately 2  
62 million outpatient visits each year for children under the age of 5 [5,6]. Estimates of the  
63 prevalence of ARI-causing pathogens generally rely on in-person healthcare visits or aggregate  
64 counts from hospitalized individuals [6-10]. Thus, these estimates likely omit cases of mild to  
65 moderate ARI in community-dwelling individuals who may not seek care for their illness [11-  
66 13].

67

68 Active, community-level monitoring of respiratory infections is essential to assess the seasonal  
69 activity of ARI-causing pathogens and can be used to inform public health prevention strategies  
70 and influence treatment decisions made at the community level. Previous respiratory pathogen  
71 surveillance studies evaluated specific subsets of the population, such as households with  
72 children, or used labor-intensive, coordinated efforts to capture a representative sample of the  
73 community, which makes such approaches difficult to replicate [14-16]. Additionally, similar to  
74 traditional respiratory surveillance networks, some of these studies relied on healthcare facility  
75 visits which have the potential to result in the nosocomial spread of respiratory pathogens [17-  
76 18]. Despite the limitations of earlier analyses, community-wide surveillance studies remain of  
77 vital importance as they provide opportunities to better understand the epidemiology of  
78 respiratory illness among symptomatic individuals with variable disease severities and  
79 healthcare-seeking behaviors.

80

81 The Seattle Flu Study Swab and Send sub-study is a novel, city-wide, cross-sectional study of  
82 home-based detection of respiratory pathogens. This study demonstrates the feasibility of  
83 using a home-based surveillance approach to assess the epidemiology of influenza and other  
84 respiratory pathogens in a community-based setting.

85

## 86 **Methods**

87

### 88 Study Design

89 The “Swab and Send” sub-study was nested within the Seattle Flu Study (SFS), a multi-armed  
90 influenza surveillance system [19]. This sub-study aimed to assess the feasibility of city-wide  
91 home-based cross-sectional respiratory pathogen surveillance, utilizing rapid delivery systems  
92 for at home collection of a nasal swab from individuals experiencing ARIs with return of  
93 specimens to the laboratory for respiratory pathogen detection. Individuals residing within the  
94 greater Seattle area with ARI symptoms were prospectively enrolled from October 2019 -  
95 March 2020. Participants resided in 89 different zip codes within King County in and around the  
96 city of Seattle. This study was approved by the University of Washington Institutional Review  
97 Board.

98

#### 99 Recruitment

100 Study recruitment occurred through 1) referrals from healthcare providers, clinics, Seattle Flu  
101 Study community kiosks (an in-person enrollment center), schools, and workplaces, 2)  
102 dissemination of printed flyers posted at community locations, and 3) posting of targeted  
103 online advertisements (e.g., Facebook, Instagram, Twitter, Google). Recruitment materials  
104 directed potential participants to the study website ([www.seattleflu.org](http://www.seattleflu.org), henceforth referenced  
105 as the “study website”). To determine their eligibility, individuals completed a screening survey  
106 on the study website by providing their age, home zip code, and information about the  
107 presence and duration of respiratory symptoms and by verifying their access to the internet.

108

109 Individuals were eligible to participate in the study if they lived within specified zip codes, had  
110 experienced new or worsening cough and/or two ARI symptoms (subjective fever, headache,

111 sore throat or itchy/scratchy throat, nausea or vomiting, runny/stuffy nose or sneezing, fatigue,  
112 muscle or body aches, increased trouble with breathing, diarrhea, ear pain/ discharge, or rash)  
113 within seven days of enrollment (Table A1), were English-speaking, had a valid email address,  
114 and had access to the internet at home. All individuals consented to participate in the research  
115 study electronically, with consent by a parent or legally-authorized representative for  
116 individuals under 18 years and concurrent assent for those between 7 and 18 years.

117

### 118 Data Collection

119 Upon consenting, participants completed an online *Enrollment Questionnaire* to provide their  
120 home address and contact information such as an email address or phone number. Participants  
121 were mailed a home swab kit within 48 hours of submitting the *Enrollment Questionnaire*,  
122 which included a *Quick Start Instruction Card* (Fig. A1), a universal viral transport media (UTM)  
123 tube (Becton, Dickinson and Company, Sparks, MD), a nylon flocked mid-turbinate swab  
124 (COPAN Diagnostics Inc., Murietta, CA), a return box with an affixed Category B UN3373 label  
125 (as required by International Air Transport Association (IATA) guidelines [20]), and a pre-paid  
126 return shipping label. Pediatric nasal swabs (COPAN Diagnostics Inc., Murietta, CA) were  
127 available for participants 5 years of age or younger. Various couriers were used to deliver home  
128 swab kits to participants across King County, depending on geographical location as determined  
129 by zip code. For the 2,398 of participants who resided within the city of Seattle, FedEx Same  
130 Day City was used to deliver kits with a target delivery time of two hours.

131

132 Upon kit receipt, participants completed an online *Illness Questionnaire* to ascertain  
133 demographics, illness characteristics, and health behaviors. Education level was only asked to  
134 participants 18 and older. Additionally, participants were asked to rate the impact of their  
135 current illness on regular activities at the time of their enrollment using a five-point Likert scale  
136 with the following levels: not at all, a little bit, somewhat, quite a bit, or very much. These  
137 categories were transformed into none, low (a little bit, somewhat), and high (quite a bit, very  
138 much).

139

140 At the end of the *Illness Questionnaire*, participants were prompted to self-collect a mid-nasal  
141 swab using the provided *Quick Start Instruction Card* (Fig. S1) included in the swab kit box.  
142 Participants were instructed to place their self-collected nasal swabs directly into the UTM tube  
143 which was pre-labeled with a unique sample barcode. Next, participants were instructed to  
144 place the UTM tube containing the self-collected nasal swab into a specimen bag, pre-packaged  
145 with an absorbent sheet, and then to put the specimen bag into the provided return shipping  
146 box. United States Postal Service (USPS) return postage and Category B UN3373 stickers were  
147 affixed to the outside of the return box. Although previous testing has demonstrated that  
148 respiratory viral RNA is stable at room-temperature in UTM for up to one week [21],  
149 participants were encouraged to return their nasal specimen within 24 hours or as soon as  
150 possible. For the subset of participants where detailed courier data was available, median  
151 delivery times were determined through the use of proof of delivery (POD) data on scheduled  
152 shipment times, completed delivery times, and mileage.

153

154 Seven days after nasal swab collection, participants were re-contacted to complete a *One Week*  
155 *Follow-Up Questionnaire* to assess the impact of their illness on behavioral outcomes such as  
156 absenteeism and healthcare-seeking behaviors (provider visits, antiviral use, etc). Care-seeking  
157 was marked as “any care” if the participant indicated they had sought care in the *Illness*  
158 *Questionnaire* or *One Week Follow-Up Questionnaire*. Any care-seeking included doctor’s office  
159 or urgent care, pharmacy, hospital or emergency department, or other.

160

161 All study questionnaires were collected through REDCap (Table A3) [22]. A full timeline of study  
162 events may be found in Table A2. Access to de-identified, aggregate study data and analysis  
163 code will be publicly available on the study website.

164

### 165 Laboratory Testing

166 When kits arrived in the study laboratory, contents of the box and deviations from return mail  
167 instructions were recorded. 200 µl of UTM was removed and subjected to RNA extraction using  
168 a MagNA Pure 96 System (Roche) and the remainder was banked at -80°C. The extracted  
169 nucleic acids were screened for respiratory pathogens using a custom, TaqMan-based Open  
170 Array panel (Thermo Fisher) and an additional SARS-CoV-2 RT-PCR research assay. Samples  
171 were subjected to the SARS-CoV-2 assay in real-time if they were collected after February 25,  
172 2020 and retrospectively if collected between January 1, 2020 and February 24, 2020 (Table A4)  
173 [23]. Samples with RNase P relative cycle threshold ( $C_{RT}$ ) values  $\leq 28$  for the Open Array assay,  
174 which has a preamplification step, and  $\leq 36$  for the SARS-CoV-2 assay were considered to  
175 contain sufficient material for pathogen detection [24]. Samples were screened for influenza A



176 H3N2, H1N1, and pan influenza A, influenza B, influenza C, respiratory syncytial viruses (RSV) A  
177 and B, human coronaviruses (hCoV) 229E, NL63, OC43, and HKU1, SARS-CoV-2, adenovirus  
178 (AdV), human rhinovirus (hRV), human metapneumovirus (hMPV), human parechovirus (hPeV),  
179 enteroviruses A, B, C, D, D68, and G, human bocavirus (hBoV), *Streptococcus pneumoniae*,  
180 *Mycoplasma pneumoniae*, and *Chlamydia pneumoniae* (Table A4).  $C_{RT}$  values for RNase P,  
181 influenza, hCoV, RSV, and hRV from 11,984 nasal samples collected between October 2019 to  
182 March 2020 at Seattle Children's Hospital were analyzed as a contemporary control of  
183 healthcare worker-collected specimens and compared to the self-collected specimens in this  
184 study.

185

#### 186 Data Analyses

187 Descriptive statistics were performed for categorical and continuous covariates. Bivariate  
188 analyses were conducted using parametric and nonparametric tests as appropriate, with  
189 statistical significance defined as  $p < 0.05$ . The Kruskal-Wallis test was used to determine p-  
190 values for study procedure compliance categories, comparing each of the three nasal swab  
191 error types to those with no errors. ANOVA was used to calculate an overall p-value for RNase P  
192 values across confidence and discomfort levels. Respiratory pathogen prevalence is defined as  
193 the total number of cases detected out of the total number of tested samples.

194

## 195 **Results**

196

#### 197 Participant Characteristics

198 A total of 4,572 participants were consented and enrolled in the SFS Swab and Send sub-study  
199 from October 16, 2019 to March 9, 2020. The majority of participants were recruited into the  
200 study through online or social media advertisements (53.9%) or through referrals from friends  
201 or family (19.3%). Of the 4,572 participants who completed the electronic consent form, 4,359  
202 (95.3%) participants also completed the *Enrollment Questionnaire* and provided a valid home  
203 address, which was required to receive a home swab kit. Participant characteristics, including  
204 age, sex, race, Hispanic ethnicity, income, education level, influenza vaccination status,  
205 healthcare-seeking status, test results, baseline impact of illness on regular activities, and  
206 recruitment method are shown in Table 1. The mean age of study participants was 36.6 (SD: 15)  
207 years old. Most (73.7%) of participants were 18-49 years old. On average, the study population  
208 was more highly educated and had a higher household income than the general population of  
209 King County. A total of 31.4% of participants had a bachelor's degree as their highest degree  
210 while 31.6% had an advanced degree. 26.6% had a household income of  $\geq$  \$150,000 per year  
211 (Table 1).

212

213 At time of enrollment, 42.0% of participants who were sent a nasal swab rated the impact of  
214 their current illness on their regular activities as high although 67.5% had not sought clinical  
215 care. The majority of study participants did not seek clinical care for their illness during the  
216 study period. A total of 27.1% of participants sought clinical care for their current illness prior to  
217 enrollment or during the study period whereas 50.1% never sought clinical care during this time  
218 frame (Table 1). In general, participants who sought care were more likely to do so after  
219 enrolling and completing their home swab kits. Among those who sought care (N=1,178), 727

220 (61.7%) participants sought care prior to enrollment and 989 (84.0%) sought care within one  
221 week after enrollment, though these categories are not mutually exclusive.

222

223 Of the 4,359 participants who received a home swab kit, 3,648 (83.7%) returned a nasal  
224 specimen to the laboratory and 3,638 (99.7%) of returned specimens contained sufficient UTM  
225 in the tube and RNase P levels for respiratory pathogen screening (Fig. 1). Influenza A (10.8%),  
226 hRV (10.4%), hCoV (8.6%), and influenza B (6.9%) were the most commonly detected pathogens  
227 (Table A5; Fig. 2). Samples collected on or after January 1, 2020 were tested for SARS-CoV-2, of  
228 which 36 out of 2,843 (1.2%) were positive for the novel coronavirus. The 3,629 self-collected  
229 nasal specimens with available RNase P data yielded a mean RNase P  $C_{RT}$  value of 19.0 (SD: 3.4)  
230 (Table A5). A contemporary comparison of  $C_{RT}$  values from healthcare worker-collected nasal  
231 specimens to self-collected nasal specimens is shown in Table A6.

232

### 233 Study Logistics

234 For the 4,359 participants who received a home swab kit, the median time between participant  
235 completion of enrollment and scheduling of the shipment was 7.2 hours [IQR: 0.45-19.6]. The  
236 total median delivery transit time to participants who received their home swab kit via FedEx  
237 Same Day City was 2.2 [IQR: 1.7 - 3.0] hours with 79% of deliveries meeting the two-hour target  
238 delivery time. A subset of the delivery time data was reported previously [25]. The median  
239 delivery time via FedEx Same Day City to participants' homes by distance from the study  
240 laboratory is shown in Fig. 3. Of the 2,398 FedEx Same Day City deliveries, there were a total of  
241 78 (3.3%) redelivery attempts. The estimated median time between nasal swab collection to

242 receipt at the study laboratory was 3.0 [IQR: 2.0, 4.0] days for the 3,648 participants who  
243 returned specimens. Of the 3,638 testable samples, the median time between shipment and  
244 completed laboratory testing was 8.0 [IQR: 7.0 - 14.0] days (Table 2).

245

#### 246 Study Procedure Completion and Compliance

247 Study procedure completion rates are shown in Fig. 1. Of the 4,359 participants who completed  
248 the *Enrollment Questionnaire* and received a home swab kit, 3,214 (73.9%) completed all study  
249 procedures. Study procedure completion and compliance by age, sex, income, education, care-  
250 seeking status, and baseline illness-impact are shown in Table 3. None of these variables were  
251 significantly associated with study procedure compliance (Table 3).

252

253 The majority of participants correctly followed instructions to package their collected nasal  
254 swab for return to the laboratory. Of the 3,648 returned nasal specimens, 3,208 (88.1%) home  
255 swab kits were returned correctly packaged. A total of 205 (5.6%) contained a sample tube  
256 labeling error, such as a missing written name or collection date, and 205 (5.6%) were  
257 mispackaged. Criteria for mispackaged samples included improper use of the provided return  
258 box, specimen transport bag, or lack thereof. Additionally, 24 (0.66%) returned specimens had a  
259 sample tube use error, such as a damaged UTM tube, a missing or misused nasal swab, or  
260 leakage. Four out of 3,648 (0.11%) returned home swab kits contained leakage and these  
261 samples were immediately disposed of upon unpackaging (Table 3).

262

263 Participants who enrolled between January 6, 2020 and March, 9, 2020 were asked to rate their  
264 confidence in correctly self-collecting their nasal swab and their discomfort level while doing so.  
265 Higher confidence and discomfort levels were significantly associated with lower RNase P C<sub>RT</sub>  
266 values ( $p < 0.001$  and  $p = 0.04$ , respectively). The average RNase P C<sub>RT</sub> value for participants who  
267 experienced strong discomfort was 1.4 lower than the average value for those who had no  
268 discomfort. The average RNase P C<sub>RT</sub> value for those who were very confident was 1.2 lower  
269 than those who were not confident at all (Fig. 4). Among the 4,359 participants who received a  
270 home swab kit, there was one (0.0%) reported adverse event related to strong discomfort while  
271 collecting the nasal swab. The affected participant's discomfort resolved within two minutes.  
272 The participant suffered no long-term effects and did not require medical attention. Results  
273 suggest that non-medically trained individuals can safely and adequately collect a nasal sample  
274 from themselves or their family members.

275

## 276 Discussion

277

278 Over the 2019-2020 influenza season, we enrolled a large cohort of participants with acute  
279 respiratory illness in a study of home-based swab collection for detection of respiratory  
280 pathogens. The majority of participants completed all study procedures and returned their  
281 nasal specimens to the study laboratory in a timely manner and in compliance with federal  
282 transport guidelines for biohazards. The majority of returned nasal specimens were adequately  
283 self-collected as quantified by RNase P C<sub>RT</sub> value. These results support the feasibility of using

284 online enrollment and self-collected nasal swabs for community surveillance of respiratory  
285 pathogens.

286

287 Existing methods to estimate the community-level prevalence of influenza rely on estimator  
288 models based on laboratory-confirmed cases and adjusted for various confounding factors  
289 including medical care seeking, collection and testing of specimens, and reporting of cases.

290 These methods are limited to medically attended illnesses and require relatively comprehensive  
291 data for accuracy, which leads to long periods of time between data collection and the  
292 availability of results [19]. In this study, we directly surveyed for influenza and other respiratory  
293 pathogens in the community allowing rapid assessment of pathogen characteristics and the  
294 associated clinical presentations among both care-seeking and non-care-seeking study  
295 populations. When combined with estimator models, on-the-ground surveillance of  
296 community-dwelling individuals with less severe illness and a wider range of demographic  
297 backgrounds may enhance our understanding of the burden of various respiratory pathogens in  
298 a community.

299

300 Similarly, estimator models with complete reliance on laboratory-confirmed cases can be  
301 limiting, especially during epidemics or pandemics in heavily-affected regions where outbreak  
302 dynamics are rapidly evolving and the capacity of the healthcare system to adequately test  
303 cases has been exceeded [19]. The benefits of direct, home-based surveillance among  
304 community-dwelling individuals can be seen in context of the current COVID-19 pandemic.

305 From January 1, 2020 to March 9, 2020, the Seattle Flu Study detected 78 cases of SARS-CoV-2

306 through direct sampling of community members including the first documented case of  
307 community transmission in the US, with 36 cases identified through the Swab and Send sub-  
308 study [25, 26]. This study enrolled and tested a large cohort of individuals with ARI symptoms  
309 across a large geographical area, half of whom did not seek clinical care prior to or during the  
310 study period. The at home study design proved to be an effective means of studying individuals  
311 infected with influenza and other respiratory pathogens, many of whom may not have been  
312 captured by traditional clinic or hospital surveillance. This demonstrates that when faced with  
313 an emerging infectious disease, home-based testing can identify cases among non-care-seeking  
314 individuals, providing essential information for pandemic identification, spread, and  
315 management.

316  
317 Limitations of this study include the enrollment of a study population that was not  
318 representative of the greater Seattle area. King County demographic data from the 2010 census  
319 shows that 49.8% of residents were male and 21.4% were 17 years of age and under, whereas  
320 our study population included 27.3% males and 7.7% minors. Additionally, the King County  
321 population is 6.0% black or African American and 8.9% Hispanic individuals whereas our study  
322 cohort was only 0.8% black or African American and 4.2% Hispanic. The median King County  
323 household income in 2016 was \$78,800 per year whereas the largest proportion (26.6%) of  
324 participants had a household income of greater than \$150,000 per year [27]. We hypothesize  
325 that factors related to lack of internet access and unfamiliarity with online systems may have  
326 contributed to lack of representativeness among certain groups in our study population. The  
327 utilization of targeted recruitment strategies aimed at enrolling a larger proportion of

328 participants who were underrepresented in this cohort including males, children, minorities,  
329 and individuals of lower socioeconomic statuses could be implemented to yield a more  
330 representative study population.

331  
332 Additionally, while most participants returned their home swab kits with no packaging or  
333 sample tube use errors at a rate concordant with a previous study [28], improvements to  
334 instructions (e.g. inclusion of instructional videos) may decrease these error rates. Further  
335 limitations of this study include use of self-collected mid-nasal swabs, which are not the gold  
336 standard for respiratory pathogen detection. However, our group has previously demonstrated  
337 that self-collected mid-nasal swabs are highly concordant with health care worker-collected  
338 nasopharyngeal swabs for detection of SARS-CoV-2 [29], with results comparable to those of  
339 previous studies on the detection of viral pathogens by patient-collected mid-nasal swabs [30-  
340 33]. In addition, the contemporary control analysis included in this study shows that  $C_{RT}$  values  
341 for pathogen-positive samples collected by healthcare workers are comparable to those of self-  
342 collected samples, with  $C_{RT}$  values for healthcare-collected swabs lower for some targets but  
343 higher for others than self-collected swabs. Finally, the requirement of internet access and  
344 delivery addresses that are easily accessible by standard shipping couriers may limit the  
345 scalability of this method in low resource or rural settings.

346  
347 In conclusion, at home surveillance with self-collected nasal swabs is a feasible method to study  
348 the community-based prevalence of influenza during seasonal epidemics on a city-wide scale.  
349 This methodology can be adapted to study a variety of respiratory pathogens affecting diverse



350 study populations with the ability to scale-up to larger sample sizes. In particular, this approach  
351 allows for the inclusion of non-care-seeking individuals in respiratory pathogen surveillance  
352 studies and may be especially useful during epidemics or pandemics when quarantine and  
353 social distancing measures are in place to reduce transmission risks.

354

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359

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361 Lutz, Deborah A. Nickerson, Lea M. Starita, and Trevor Bedford designed the study including the  
362 laboratory and data informatics procedures. Ashley E. Kim wrote the manuscript, developed the  
363 data collection instruments and logistics infrastructure for study implementation, and managed  
364 day-to-day responsibilities of the study. Naomi Wilcox performed the data analysis for the  
365 manuscript. Chelsey Graham developed the logistics infrastructure of the study. Elisabeth  
366 Brandstetter managed the IRB and assisted with quality assurance of the study. Denise J.  
367 McCulloch contributed to the implementation and quality assurance of the study. Jessica  
368 Heimonen wrote the background section of the manuscript and critically revised the  
369 manuscript. Victoria Lyon and Rachel E. Geyer contributed to the design of the home-collection  
370 kits, including the Quickstart Instructions Card, as well as managing the kit fabrication  
371 procedures. Peter D. Han managed laboratory procedures of the study. Misja Ilcisin, Kairsten A.

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382

### 383 **Competing Interests**

384 Helen Y. Chu receives research support from Sanofi, Cepheid, and Genentech/Roche and is a  
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392 Misja Ilcisin, Kairsten A. Fay, Jover Lee, Thomas R. Sibley, and Trevor Bedford declare no  
393 competing interests.

394

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528 **Table 1:** Clinical and sociodemographic characteristics of enrolled participants, October 16, 2019 -  
 529 March 9, 2020

	N=4,359 (%)
<b>Age</b>	
<5y	128 (2.9%)
5-17y	208 (4.8%)
18-49y	3212 (73.7%)
50-64y	614 (14.1%)
>=65y	192 (4.4%)
<b>Sex</b>	
Male	1191 (27.3%)
Female	2451 (56.2%)
Other	19 (0.4%)
<b>Race</b>	
American Indian/ Alaska Native	17 (0.4%)
Asian	724 (16.6%)
Native Hawaiian/ Pacific Islander	7 (0.2%)
Black/African American	37 (0.8%)
White	2542 (58.3%)
Other	92 (2.1%)
Multiple	188 (4.3%)
<b>Hispanic ethnicity (N=2856)</b>	183 (4.2%)
<b>Income</b>	
≤\$25K	196 (4.5%)
\$25-50K	367 (8.4%)
\$50-100K	860 (19.7%)
\$100-150K	738 (16.9%)
≥\$150K	1160 (26.6%)
<b>Education level</b>	

Graduated high school/obtained GED or less	109 (2.5%)
Some college (including vocational training, associate's degree)	492 (11.3%)
Bachelor's degree	1371 (31.5%)
Advanced degree	1377 (31.6%)
<b>Care-seeking</b>	
Any care prior to enrollment or during study period	1182 (27.1%)
No care prior to enrollment or during study period	2183 (50.1%)
<b>Illness impact on regular activities at enrollment</b>	
None	243 (5.6%)
Low	1597 (36.6%)
High	1831 (42.0%)
<b>How participant heard about the study</b>	
Saw an ad on Facebook/Instagram/Twitter	1369 (31.4%)
Referral from a friend/family member	841 (19.3%)
Other online	667 (15.3%)
Saw an ad on Google	314 (7.2%)
Referral from my place of work	280 (6.4%)
Other	172 (3.9%)
Saw a Seattle Flu Study kiosk	86 (2.0%)
Email/Seattle Community Pulse	86 (2.0%)
Referral from a healthcare provider, travel clinic, or immigrant/refugee health screening	60 (1.4%)
Referral from my child's school	29 (0.7%)

530

531 **Table 2:** Study Logistics & Turnaround Time Metrics  
532

Metric	Time (Median [IQR])
Completed enrollment to shipment scheduled (hours) <sup>a</sup>	7.2 [0.45-19.6]
Delivery time to participant's home (hours) <sup>b</sup>	2.2 [1.7-3.0]
Nasal swab collection to returned specimen received at the laboratory (days) <sup>c</sup>	3.0 [2.0-4.0]
Shipment of home swab kit to participant's home to completed laboratory testing (days) <sup>d</sup>	8.0 [7.0-14.0]

533  
534 <sup>a</sup> Time between participant completion of the *Enrollment Questionnaire* and scheduled shipment of the  
535 home swab kit

536 <sup>b</sup> FedEx Same Day City was used to rapidly deliver home swab kits within the city of Seattle. Median  
537 FedEx Same Day City delivery times from ordering the shipment to arrival at the participant's residence,  
538 adjusting for redeliveries.

539 <sup>c</sup> Estimated time between nasal swab collection, measured by completion of the *Illness Questionnaire &*  
540 *Nasal Swab Collection* survey, and the return of completed home swab kits at the laboratory. Completed  
541 home swab kits were returned via pre-paid USPS Priority Mail.

542 <sup>d</sup> Time between scheduled shipment of home swab kits to participants' homes and available results for  
543 tested specimens

544 **Table 3:** Clinical and sociodemographic characteristics of enrolled participants, October 16, 2019 -  
 545 March 9, 2020 by study procedure completion and compliance

	Study procedure completion		Study procedure compliance				P value*
	Returned Nasal Swab N=3638	Completed All Study Procedures N=3214	Mail Packaging Error <sup>†</sup> N=205	Sample Tube Use Error <sup>§</sup> N=24	Sample Tube Labeling Error <sup>¶</sup> N=205	No Packaging or Sample Tube Errors N=3211	
<b>Age</b>							0.11
<5y	110 (3.0%)	89 (2.8%)	9 (4.4%)	1 (4.2%)	6 (2.9%)	92 (2.9%)	
5-17y	173 (4.8%)	149 (4.6%)	12 (5.9%)	0 (0%)	16 (7.8%)	149 (4.6%)	
18-49y	2638 (72.5%)	2324 (72.3%)	144 (70.2%)	15 (62.5%)	141 (68.8%)	2339 (72.8%)	
50-64y	545 (15.0%)	496 (15.4%)	33 (16.1%)	6 (25.0%)	29 (14.1%)	480 (14.9%)	
>=65y	168 (4.6%)	153 (4.8%)	6 (2.9%)	2 (8.3%)	10 (4.9%)	150 (4.7%)	
<b>Sex</b>							0.38
Male	1142 (31.4%)	1013 (31.5%)	70 (34.1%)	8 (33.3%)	70 (34.1%)	994 (31.0%)	
Female	2340 (64.3%)	2178 (67.8%)	115 (56.1%)	13 (54.2%)	118 (57.6%)	2097 (65.3%)	
Other	18 (0.5%)	15 (0.5%)	3 (1.5%)	0 (0%)	1 (0.5%)	14 (0.4%)	
<b>Income</b>							0.81
<= \$25K	180 (4.9%)	161 (5.0%)	5 (2.5%)	1 (4.2%)	9 (4.4%)	164 (5.1%)	
\$25-50K	344 (9.5%)	315 (9.8%)	21 (10.3%)	2 (8.3%)	27 (13.2%)	294 (9.2%)	
\$50-100K	818 (22.5%)	760 (23.6%)	39 (19.0%)	10 (41.7%)	49 (23.9%)	716 (22.3%)	
\$100-150K	700 (19.2%)	639 (19.9%)	33 (16.1%)	2 (8.3%)	32 (15.6%)	635 (19.8%)	
>=\$150K	1129 (31.0%)	1042 (32.4%)	69 (33.7%)	6 (25.0%)	48 (23.4%)	1010 (31.5%)	
<b>Education level</b>							0.53

Graduated high school/obtained GED or less	101 (2.8%)	80 (2.5%)	9 (4.4%)	0 (0%)	10 (4.9%)	81 (2.5%)	
Some college (including vocational training, associate's degree)	449 (12.3%)	414 (12.9%)	20 (9.8%)	5 (20.8%)	32 (15.6%)	395 (12.3%)	
Bachelor's degree	1324 (36.4%)	1220 (38.0%)	67 (32.7%)	5 (20.8%)	58 (28.3%)	1189 (37.0%)	
Advanced degree	1328 (36.5%)	1229 (38.2%)	68 (33.2%)	10 (41.7%)	66 (32.2%)	1188 (37.0%)	
<b>Care-seeking</b>							0.80
Any care prior to enrollment or during study period	1138 (31.3%)	1077 (33.5%)	52 (25.4%)	7 (29.2%)	63 (30.7%)	1013 (31.5%)	
No care prior to enrollment or during study period	2136 (58.7%)	2136 (66.5%)	114 (55.6%)	13 (54.2%)	105 (51.2%)	1912 (59.5%)	
<b>Illness impact on regular activities at enrollment</b>							0.07
None	234 (6.4%)	203 (6.3%)	17 (8.3%)	1 (4.2%)	11 (5.4%)	205 (6.4%)	
Low	1521 (41.8%)	1373 (42.7%)	90 (43.9%)	10 (41.7%)	73 (35.6%)	1345 (41.9%)	
High	1754 (48.2%)	1637 (50.9%)	81 (39.5%)	10 (41.7%)	107 (52.2%)	1564 (48.7%)	

546

547 \* Kruskal-Wallis test used to determine p-values for study procedure compliance categories (excludes

548 first three columns)

549 † Mail packaging errors include returning the nasal specimen in a damaged box, a different box than the

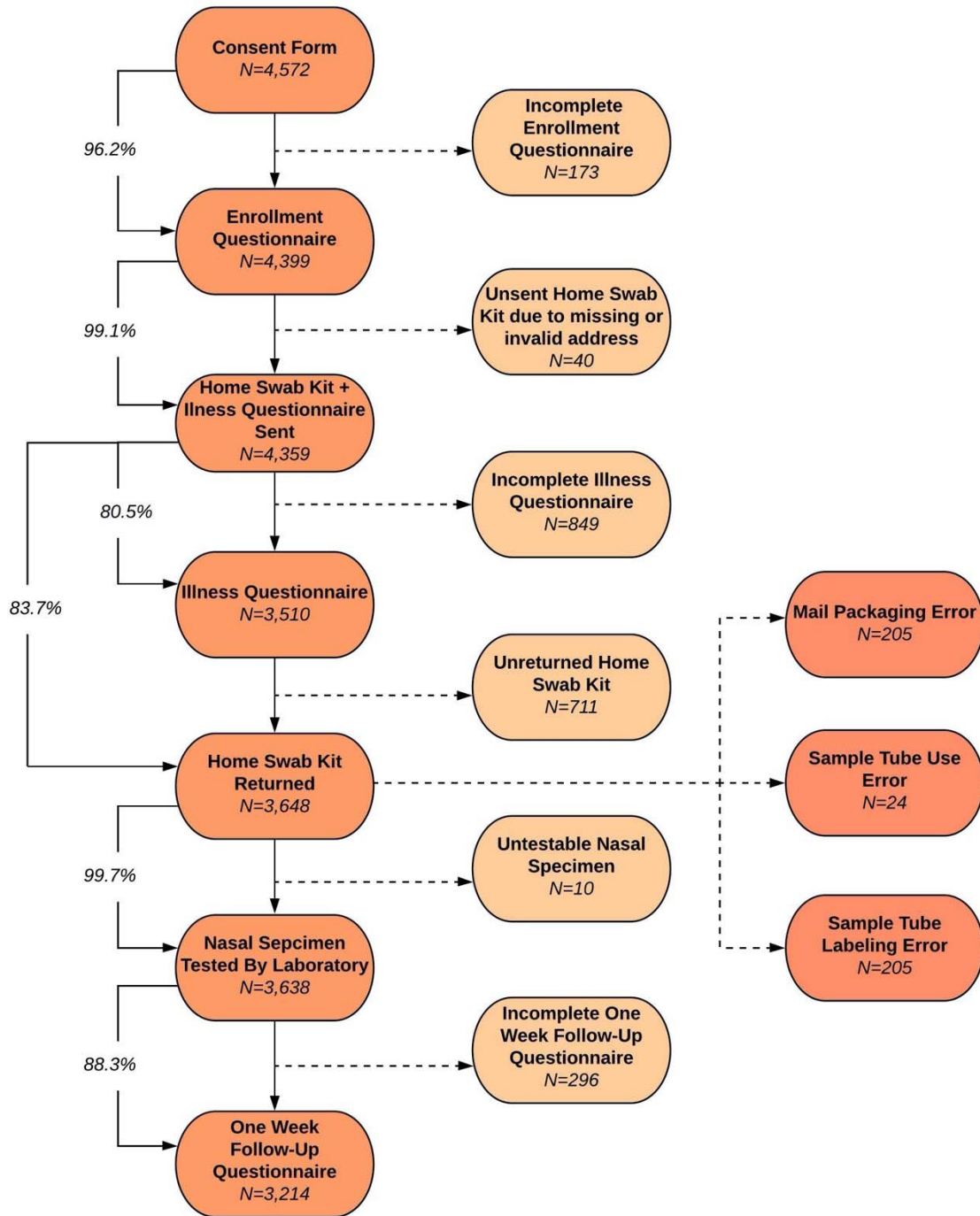
550 one provided, an improperly closed box, or an improperly used specimen transport bag or lack thereof

551 § Sample tube use errors include returned nasal specimens with a damaged or broken UTM tube, an

552 absent swab, or leakage

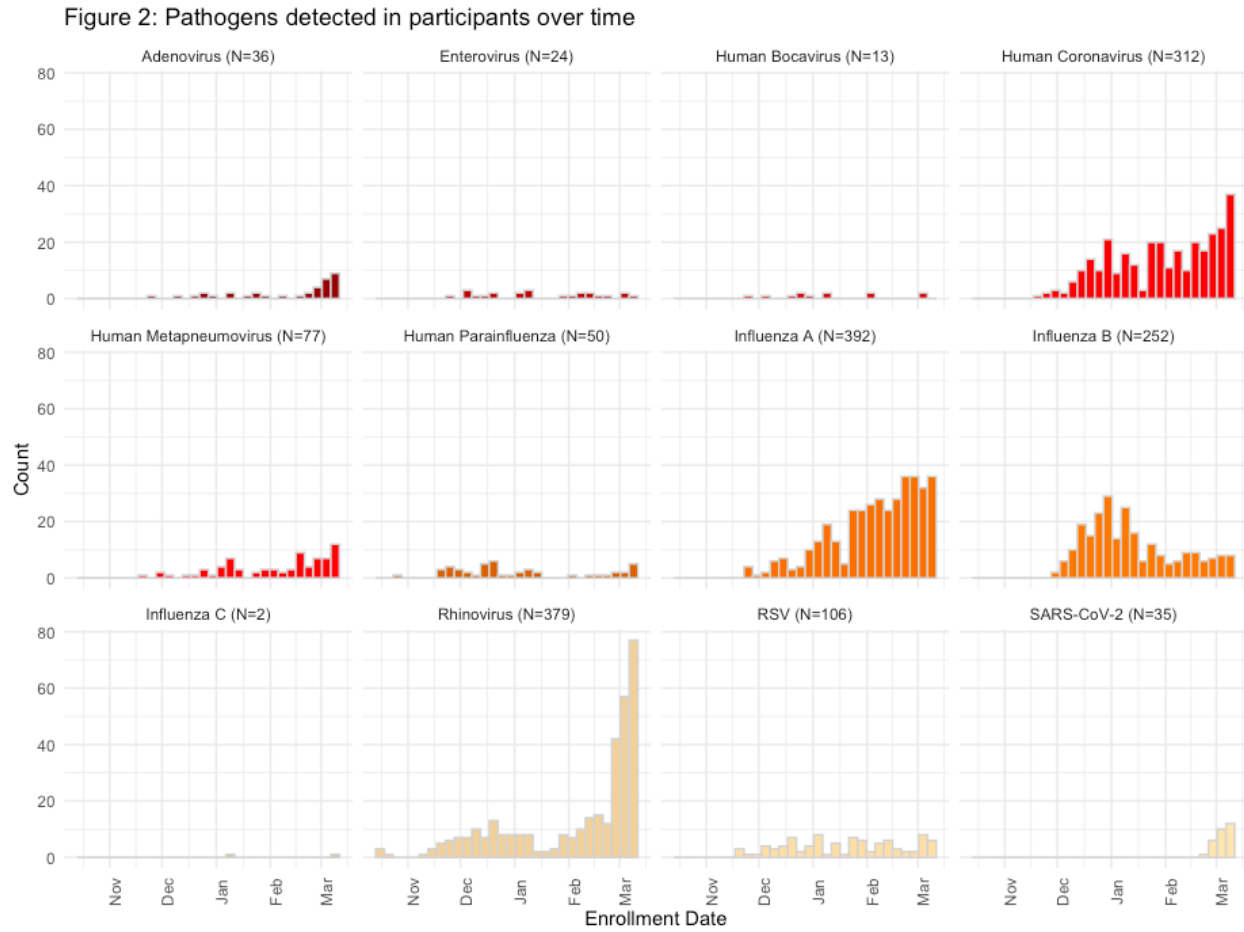
553 ¶ Sample tube labeling errors include a missing written full name or date of collection on the UTM tube

554 **Figure 1: Study procedure completion rates**  
555



556

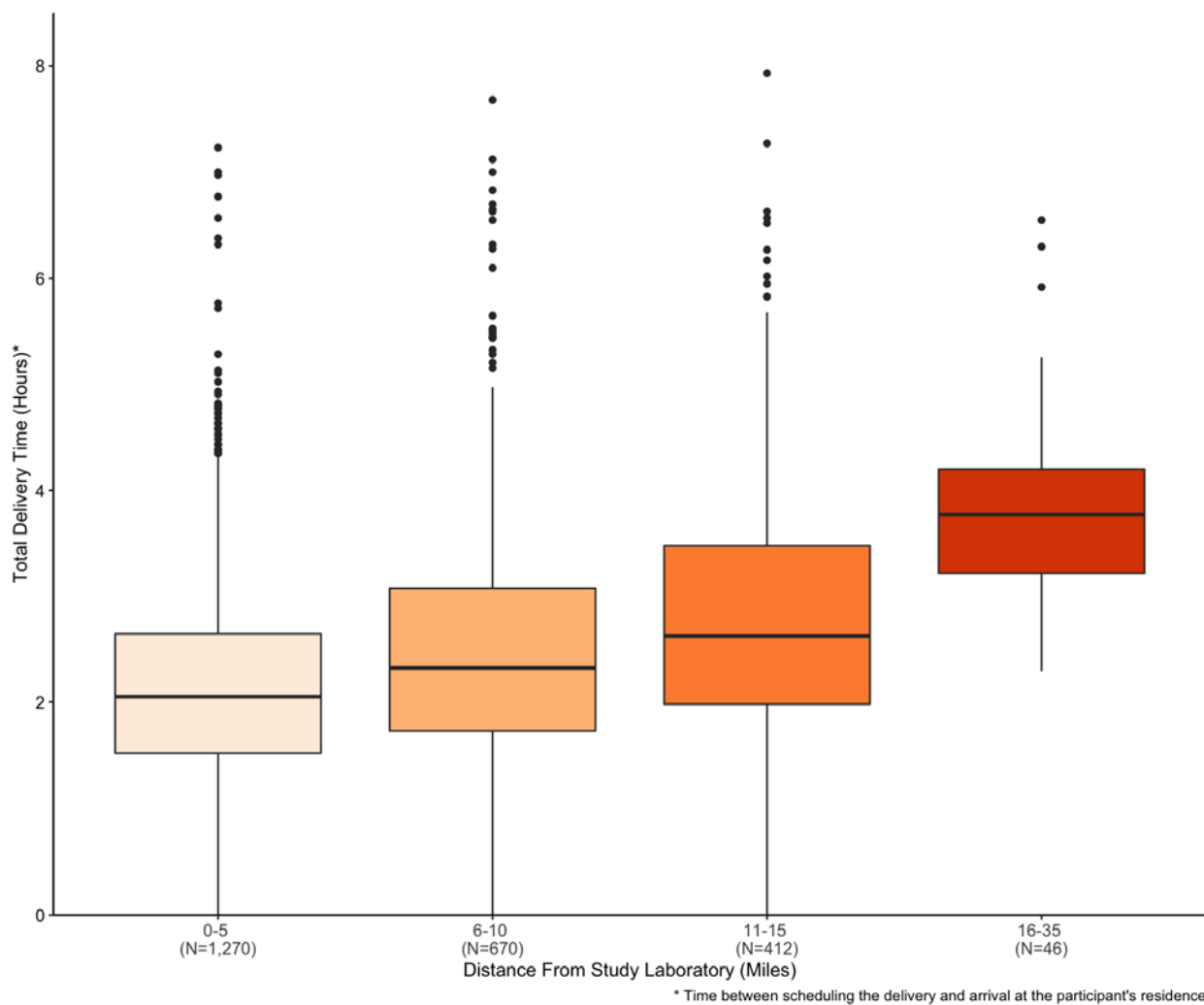
557 **Figure 2: Pathogens detected in participants over time**  
558



559



560 **Figure 3:** Median delivery times of home swab kits to participants by distance from study laboratory  
561 (N=2,398)



562

563 **Figure 4: Average RNase P  $C_{RT}$  values by discomfort of and confidence in home swab collection**  
564

