DOT/FAA/AM- 26/24
Aviation Safety
Office of Aerospace Medicine
Washington, D.C. 20591

Analysis of Kiosk-Based Remote Exams for Aeromedical Certification: Proof of Concept and Preliminary Diagnostic Performance Studies

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September 2026

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Technical Report Documentation Page

1. Report No. DOT/FAA/AM-26/24	2. Title & Subtitle Analysis of Kiosk-Based Remote Exams for Aeromedical Certification: Proof of Concept and Preliminary Diagnostic Performance Studies
3. Report Date September 21, 2026	4. Performing Organization Code N/A
5. Author(s) Clayton T. Cowl, MD, MS	6. Performing Org Report Number N/A
7. Performing Organization Name & Address Mayo Clinic, Section of Transportation Medicine, Division of Public Health, Infectious Diseases, and Occupational Medicine	8. Contract or Grant Number 6973GH-23-T-00009
9. Sponsoring Agency Name & Address Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	10. Type of Report & Period Covered Technical Report
11. Supplementary Notes Author ORCID: 0000-0001-6714-0081 DOI: https://doi.org/10.21949/z3h2-jr91	
12. Abstract This study evaluated the preliminary feasibility, user acceptance, and diagnostic performance of kiosk-based telemedicine for selected components of aeromedical certification examinations. Two sequential studies were conducted. In Phase I, 15 pilots completed conventional in-person and simulated kiosk-based remote examinations to assess technical feasibility, user acceptance, and agreement of examination findings. In Phase II, four non-pilot patients with known potentially safety-sensitive physical findings and one control participant without such findings were examined remotely by five physicians, with results compared against in-person examinations. Phase I demonstrated the feasibility of remotely performing several examination components, although certain required tests were obtained separately and some examination elements could not be adequately assessed using the study configuration. Pilots generally reported favorable experiences, while physicians identified limitations in instrumentation, examination quality, and training. Remote and in-person findings were similar in the small Phase I sample. In Phase II, preliminary diagnostic performance estimates were 85% sensitivity, 100% specificity, 100% positive predictive value, and 62.5% negative predictive value for the study's predefined safety-sensitive findings. These estimates were based on a small, selected sample with repeated physician assessments and did not establish diagnostic equivalence. Overall, the studies demonstrated preliminary technical feasibility and user acceptance for selected examination components but did not establish an equivalent level of safety or readiness for operational implementation. Further technology development and larger, appropriately designed validation studies are needed.	
13. Key Word Telemedicine, Aviation medicine, Physical examination, Clinical validation, Medical examiner, Healthcare accessibility, Flight safety	14. Distribution Statement Document is available to the public through the National Transportation Library: https://ntl.bts.gov/ntl

15. Security Classification (of this report) Unclassified	16. Security Classification (of this page) Unclassified	17. No. of Pages 49

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List of Abbreviations

Acronym	Abbreviation Explained
AMCD	Aerospace Medical Certification Division
AME	Aviation Medical Examiner
AMCS	Aerospace Medical Certification Subsystem
CACI	Conditions AMEs Can Issue
CLIA	Clinical Laboratory Improvement Amendments
ECG	Electrocardiogram
EMR	Electronic Medical Record
FAA	Federal Aviation Administration
HIPAA	Health Insurance Portability and Accountability Act
NPV	Negative Predictive Value
OSA	Obstructive Sleep Apnea
PPV	Positive Predictive Value
QA	Quality Assurance
REDCap	Research Electronic Data Capture
ROM	Range of Motion
SSRI	Selective Serotonin Reuptake Inhibitor

EXECUTIVE SUMMARY

The COVID-19 pandemic revealed a gap in the aeromedical certification process in the context of a public health emergency, as pilots had difficulty accessing practices to undergo in-person medical certification exams. This required the FAA to place an emergency moratorium on certification deadline requirements temporarily. The situation was undesirable in that it forced the agency to remove one of the ways to ensure human reliability within aerospace operations. Prompted by a feasibility assessment introduced by the FAA Office of Aerospace Medicine in 2023 through work done by the Mitre Corporation[1], we proposed the use of a kiosk model of telemedicine technology utilizing medical instrumentation to perform aeromedical certification examinations virtually as an add-on to the standard office visit. This report summarizes a proof-of-concept study to determine if the logistics of a kiosk model were conducive to this use application and, based upon user acceptance, to conduct a second study to determine if a panel of physicians examining a small cohort of patients remotely using the kiosk model would be able to readily identify safety-sensitive issues documented during an in-office exam used as a control – in essence, taking sequential steps to assess whether an equivalent level of safety can be achieved through telemedicine technology.

We conducted a proof-of-concept through a case series of 15 pilots applying for FAA medical certificates who underwent an exam using a traditional face-to-face office visit as a control, followed by a remote exam utilizing a kiosk model. Pilots, who were seen by a different examiner for each type of evaluation, underwent the same required testing for each session. Pilots and examiners were surveyed to assess ease of kiosk use, satisfaction with overall experience, quality of the examination, satisfaction with technical aspects of the kiosk model, and technology security and interruptions. The findings of each type of exam (in-office vs. kiosk) were also compared for variation. Quantitative variables such as vital signs, visual acuity, and weight were similar. Both pilot applicants and examiners found the technology easy to use and, aside from initial technical glitches that improved with experience, the outcomes of each assessment were identical between in-office and remote kiosk examination experiences.

The second phase of the project involved enrollment of five (5) non-pilot patients who were then evaluated remotely using the kiosk model. These findings were compared with a control: a physician performing the examination in person. Patients were screened and selected for known physical abnormalities that would be considered potential safety risks if they were actually pilots, findings that would require a physical exam to diagnose (e.g., heart murmurs, cataracts, neurological conditions), with one patient serving as a control who had no known safety-sensitive physical exam abnormalities. Calculations were then performed to assess diagnostic performance for detecting safety-sensitive physical abnormalities (e.g., sensitivity, specificity, positive and negative predictive values). This was followed by development of a semi-quantitative scoring matrix, and both the patients and physicians who performed the virtual exams were surveyed to assess satisfaction and perceptions of exam accuracy and ease of use.

RATIONALE AND BACKGROUND

The COVID-19 pandemic revealed a gap in the aeromedical certification process in the context of a public health emergency, as pilots had difficulty accessing practices to undergo in-person medical certification exams. This required the FAA to place an emergency moratorium on certification deadline requirements temporarily. The FAA Office of Aerospace Medicine (OAM) funded a technological feasibility assessment through a “telemedicine innovation challenge” to gauge marketplace best practices, and ultimately was able to view mature telemedicine technology to accomplish 19 and partially complete 10 elements of the FAA's aeromedical certification exam.[1]

This summary paper outlines two sequential studies undertaken at Mayo Clinic in Rochester, Minnesota, to potentially address an alternative for aeromedical certification access concerns outlined by the FAA within the “telemedicine innovation challenge” announced in 2023. The projects in this report involved a kiosk-based model that would allow for improved access and convenience for pilots and likely equal or, in some ways, even exceed, the quality of physical exams performed in the traditional face-to-face format (e.g., allowing for digital recording to be used for quality assurance (QA) initiatives). The kiosk model is not designed to replace the traditional office visit, but instead to provide a potential alternative for a subset of pilots. The kiosk model included technology to obtain vital signs, visual acuity, color vision, field of vision, and conversational voice testing; it also contained an electronic stethoscope, an electronic otoscope, and a highly maneuverable camera that allowed for magnification of visualized physical exam findings. The kiosk model would meet requirements for patient privacy, data security, and infectious safety, and would be manned by aviation medical examiners remotely to theoretically issue medical cards via mail (or through the kiosk itself) to the pilot once all data are reviewed and a certification determination made – or to defer adjudication of the exam if a safety-sensitive abnormality or condition was identified. The use of the kiosk model would be tailored for a subset of applicants without known significant medical conditions requiring Special Issuance or other waivers, while aviators with complex medical conditions would use existing in-person office-based models.

PHASE #1: PROOF-OF-CONCEPT

Study Aims

1. Assess viability of using a kiosk model in clinical practice focused on regulatory assessment with an AME performing the exams remotely.
2. Determine technological limitations in instrumentation and software used within a kiosk model.
3. Obtain satisfaction data from pilots and AMEs after experiencing forensic/regulatory physical examinations remotely for simulated certification of safety-sensitive maneuvers (i.e., operation of aircraft).
4. Study differences in remote versus in-person models for establishing aeromedical certification.

Methods and Study Design

Inclusion Criteria

1. Any Mayo Clinic patient aged 18-85 scheduled for a flight physical within the Mayo Clinic Section of Transportation Medicine.

Exclusion Criteria

- Inability to operate a smartphone or use online applications
- Patients/pilots being seen for a consultation only, without completing the FAA medical application form and completing a physical examination
- Patients/pilots with medical conditions requiring additional reports or consultations for obtaining or renewing a Special Issuance Authorization (a waiver)

An overview of a proof-of-concept study process flow is outlined in Figure 1.

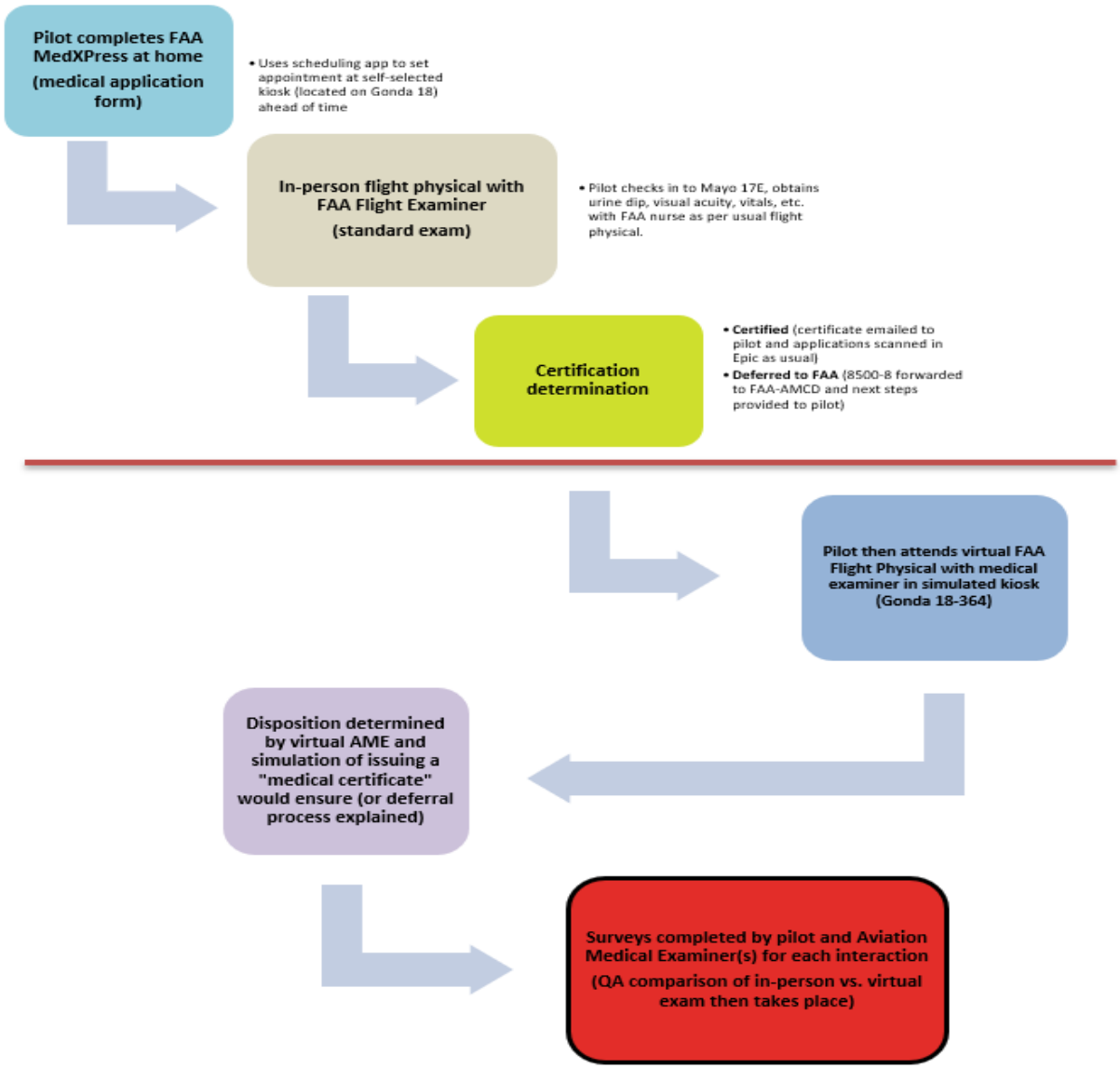


Figure 1.
Process Flow for Proof-of-Concept Assessment of Kiosk Model to Simulate Flight Physicals

Pilots scheduled for routine flight physicals at Mayo Clinic were contacted by the study coordination team telephonically and offered an opportunity to participate in the study. If willing, the pilot consented verbally to participate prior to attending the visit on the Mayo Clinic campus. The pilot used a personal smartphone or web-based application/portal to create an account, provide proof of identity, schedule their virtual appointment (with the kiosk model set up on Mayo Clinic's Gonda Building, 18th Floor (a Mayo Clinic clinical location) as the only option for study purposes), and receive an electronic credential to log in to the kiosk device.

The process flow for the virtual model proceeded as follows:

Process Flow for Kiosk-based Exams

A. Prior to Visit:

1. Physician(s) add availability to electronic calendar
2. Pilot makes appointment with electronic smartphone application, selecting date/time/location/provider
3. Pilot goes to www.faa.gov and accesses MedXPress electronic medical certification form, completing all requested demographics, medical history, and medications taken (FAA confirmation number generated after it is submitted on the web-based FAA platform as per standard protocol for usual flight physical process)

B. Once Pilot Arrives on Mayo Campus:

4. Pilot reports to clinical area (Mayo 17E) at designated date/time as outlined in patient portal and undergoes usual Mayo Clinic nursing assessment supporting the FAA examination, including photo ID check, vital signs, urine dip, visual acuity check, and ensures pilot has FAA MedXPress confirmation number available
5. Vital signs obtained
    - Vital signs – Height (in), weight (pounds), bp, pulse
    - Vision testing acuity – distant, near, intermediate
    - Color vision testing (Waggoner)
    - Phorias
    - Field of vision
    - Urine dip – information from urine dip provided to pilot
    - ECG – (one at age 35 and then annually at age 40 or greater) – to be done at Mayo prior to standard exam
    - Hearing – 6 ft conversational voice
6. In-office Provider (Mayo AME) reviews history, medications, etc. with pilot
7. Physical exam – disrobe as needed
    - Head, ENT, Eyes, Ears
    - Skin (identifying body marks, scars, tattoos)
    - Lymphatics
    - Heart
    - Lungs
    - Abdomen

- Extremities
- Neurological / Musculoskeletal
- Mental Status (routine observational component only; no structured psychiatric assessment or evaluation of a known mental health condition was performed)
- General (record obesity, etc.)

8. Disposition (with issuance of actual certificate)
   - **Issue** – medical certificate to pilot
   - **Defer** – to AMCD at the FAA (data sent by AME provider using usual FAA online system)
   - **Deny** – typically not done by AME (would normally defer to the FAA before denial decision)
9. Processing
   - Testing results collected and uploaded by AME – sent electronically to AMCS/DIWS in OKC with electronic medical application
10. Pilot then attended Kiosk-based Medical Certification Examination on Gonda 18-364
    - Pilot enters simulated passcode from app to enter kiosk software in exam room
11. Connection made with virtual AME and photo ID from enrollment checked (or shown to AME via the kiosk camera as needed)
12. Data obtained utilizing instructions from the AME performing exam remotely (using instruments in the kiosk)
    - Vital signs – Height (in), weight (pounds), bp, pulse [Wellvi]
    - Vision testing acuity – distant, near, intermediate [Titmus with remote technician]
    - Color vision testing [Ishihara plates were used for this research comparison but are not currently accepted for FAA airman color-vision screening.]
    - Phorias [Titmus with remote technician]
    - Field of vision [Visual confrontation from monitor lights]
    - Urine dip – information from urine dip provided to AME from Mayo 17E during in-office exam
    - ECG – (one at age 35 and then annually age 40 or greater) – if required, done at Mayo prior to standard exam and data shared with AME performing kiosk exam
    - Hearing – 6 ft conversational voice (assessed by AME remotely)
13. AME performing kiosk-based exam reviews history, medications, etc. with pilot
14. For any future operational model, the applicant would need to complete the applicable FAA pre-examination requirements and provide required Special Issuance, Conditions

AMEs Can Issue (CACI), mental health checklist, or other supporting documentation before the appointment. The operational workflow must define how documents are securely submitted, who uploads or transmits them to the FAA Document Imaging Workflow System (DIWS), how the AME reviews them before making a certification decision, and which authorized entity retains the records. These processes were not evaluated in this simulated study.

15. Physical exam – disrobe as needed
    - Head, ENT, Eyes, Ears (instrumentation in kiosk model includes otoscope)
    - Skin (identifying body marks, scars, tattoos with kiosk camera)
    - Heart (electronic stethoscope)
    - Lungs (electronic stethoscope)
    - Abdomen (visual only)
    - Extremities (visualize and perform various maneuvers)
    - Neurological / Musculoskeletal (range of motion, balance, etc.)
    - Mental Status (routine observational component only; no structured psychiatric assessment or evaluation of a known mental health condition was performed)
    - General (record evidence for obesity, etc.)
16. Disposition (all options simulated in the study – pilots had already completed actual flight physical)
    - **Issue** – medical certificate (in a future operational model, delivery could occur by mail or by a secure electronic method if authorized by applicable FAA policy and law)
    - **Defer** – to AMCD at the FAA
    - **Deny** – typically not done by AME (would normally defer to the FAA before denial decision)

C. Surveys:

a. Sent to pilot and AMEs performing kiosk exam after both in-person and simulated exams completed

b. Once survey completed by pilot or AME, participation gift sent.

c. Physicians were surveyed each time a kiosk-based examination was conducted

The kiosk model for this proof-of-concept project involved a computer and instrumentation set up in an existing examination room. For the purposes of the proof-of-concept study, an enclosed examination room at the Mayo Clinic was used that was outfitted with a simulated kiosk system that included a monitor, instruments, and seating. The study report does not document whether a chaperone was offered or used. Future protocols should establish chaperone, privacy, consent, and emergency-assistance procedures, particularly when disrobing or sensitive

examination elements are involved. The small, predominantly male proof-of-concept sample does not support conclusions about acceptability across applicant populations.

The kiosk contained technology to enroll a pilot for the exam, confirm identity, and perform remote examinations in a secure and confidential environment; AMEs simulated opening MedXPress and using the available form (Form 8500-8) since the pilot had already completed a flight physical earlier that day. Because of CLIA regulations for laboratory certification, a result for the required urinalysis or urine dip was obtained at the Mayo lab as part of the standard flight physical, and the final results report was shared with the AME on a screen (or patient portal), which was then recorded by the AME. Similarly, ECGs required for Class I exams were obtained prior to use of the kiosk and were available for the kiosk exam.

Results

Table 1 outlines the participant demographics. The distribution of male sex in the proof-of-concept cohort was similar to that overall of U.S. certificate holders (11% female certificate holders). Participants were slightly older than the current average of 39.6 years, reflecting a pool of more experienced private pilots (many of whom attended the Mayo Clinic Executive Health Program) and/or professional pilots who obtain flight physicals at Mayo Clinic (Table 2).

Figure 2 summarizes the survey responses from participant pilots enrolled in the proof-of-concept project. Perceptions of ease of use, convenience, whether disrobing in a virtual environment was awkward or uncomfortable, and a sense of whether the kiosk model provided valid results were surveyed utilizing a Likert scale. Pilots generally felt that establishing an account and logging into the system was easy, that security measures were adequate, and that manipulating the instruments themselves while being instructed what to do by the provider remotely was satisfactory. Most felt that obtaining urine and electrocardiogram testing separately was not a burden, and that disinfecting the keyboard and instrumentation was moderately important. Pilots felt that the kiosk model was convenient, and they supported the concept of a kiosk model for performance of flight physicals but would not necessarily be willing to pay more than a standard office visit for that convenience. The applicant survey did not separately assess satisfaction with vision-testing procedures; its ancillary-testing questions addressed vital signs, urine testing, and electrocardiography. Accordingly, the survey results should not be interpreted as evidence of applicant acceptance of the vision-testing approach.

Table 1.
Age and Sex Demographics for Proof-of-Concept Study Subjects

	Sex (n, %)	Age (mean), years
Male	13 (87%)	55.1
Female	2 (13%)	40.5

Table 2.
Distribution of Certificate Holders in Proof-of-Concept Study

	(n, %)
Student pilot	1 (6%)
Professional Pilot	2 (13%)
Private Pilot	12 (80%)
Pilots who held Special Issuance Authorization and/or were CACI qualfied (but required no testing)	4 (27%)

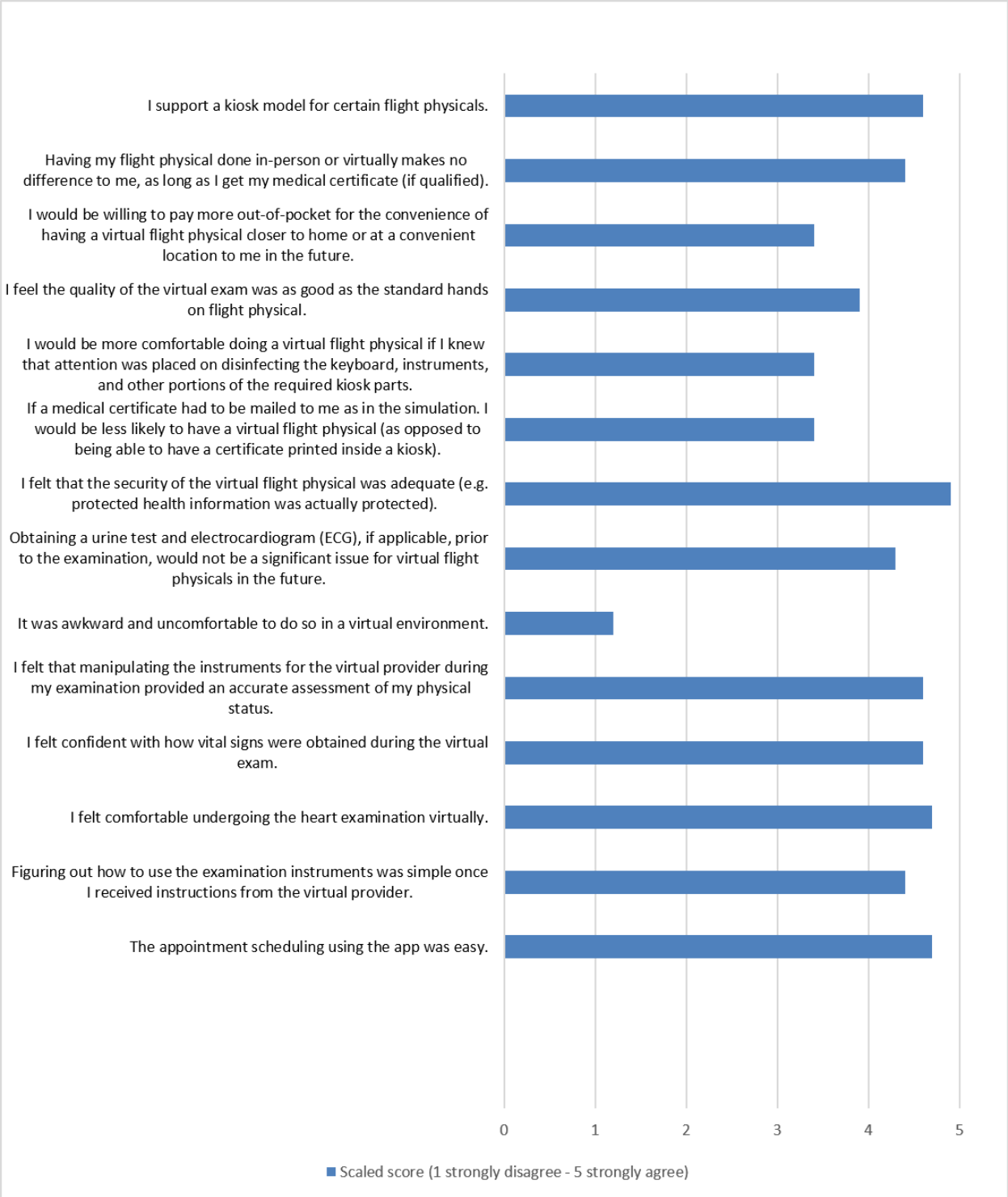
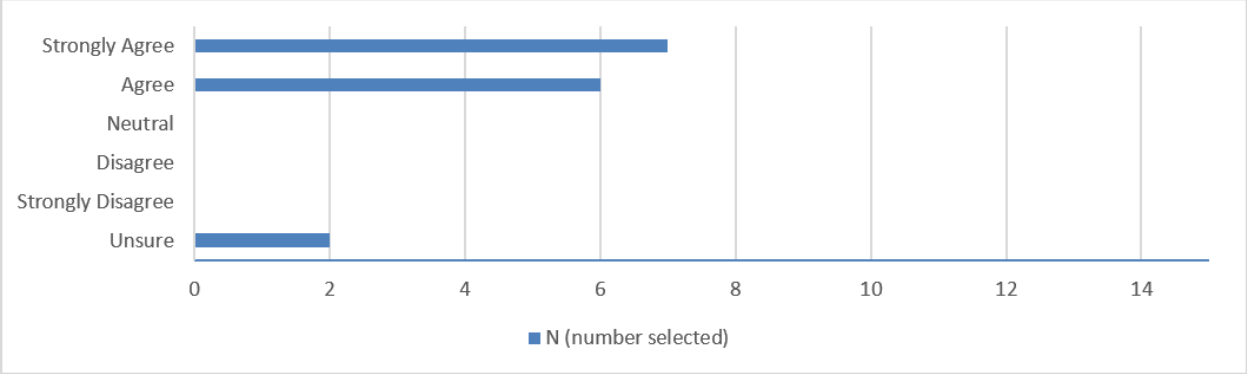


Figure 2.
Study subject responses after use of kiosk model.

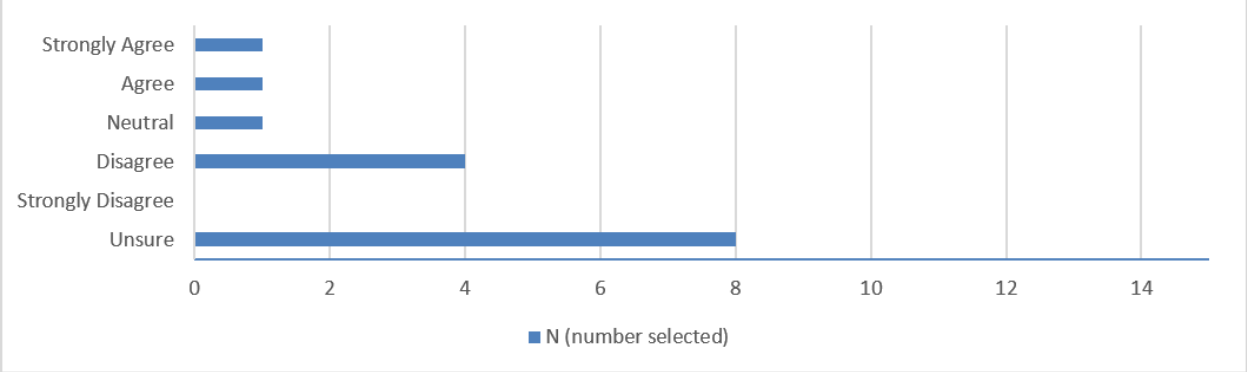
Figure 3 shows survey results obtained from AMEs enrolled in the proof-of-concept study. AMEs generally felt that logging on to and using the software within the kiosk system was easy to perform, and that the data security provided was favorable. Physicians generally indicated that use of instrumentation in the kiosk model was acceptable, even when handled by the patient/pilot, but more difficult to utilize than a standard office-based experience. Most AMEs asked the pilot to disrobe during the remote visit but were unsure of physical exam findings when using the instrumentation, and although most AMEs supported use of the technology in the future, the simulated kiosk used in the proof-of-concept was inferior to an in-person office visit and was not yet ready for "prime time." Only one responding AME indicated that virtual flight physicals appeared ready for 'prime time'; the remaining responses reflected substantial uncertainty or disagreement. These findings support continued research and system development, not operational deployment.

Figure 3.
Survey results obtained from AMEs participating in proof-of-concept study

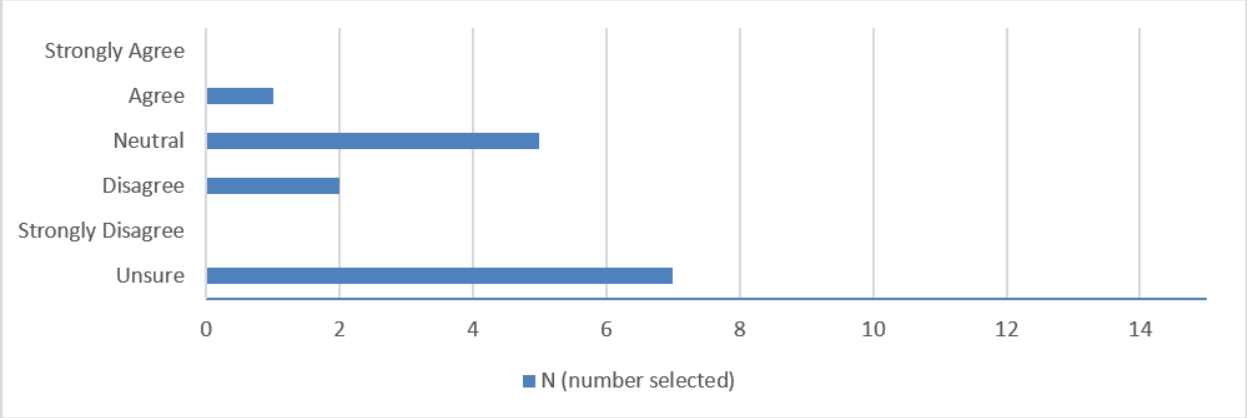
1. I had no difficulty obtaining and using the MedXPress confirmation number for the virtual flight physical from the pilot.



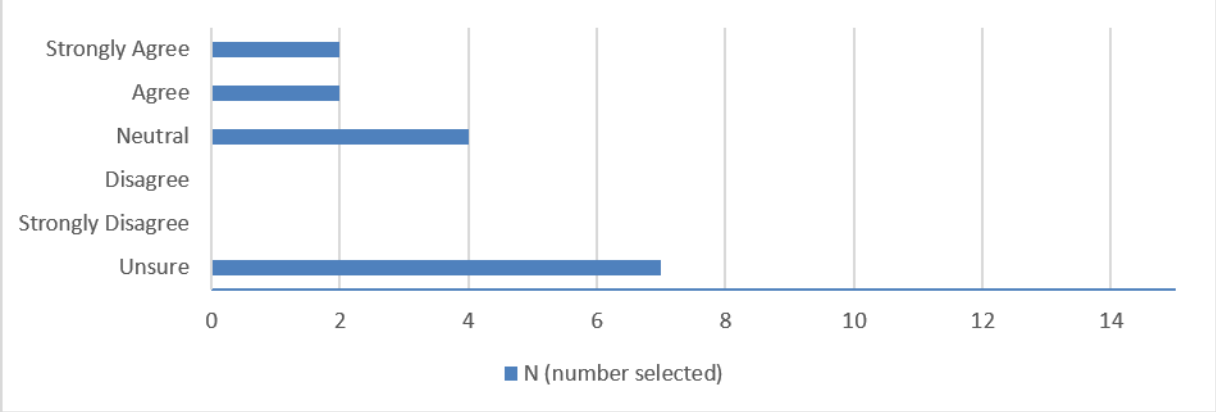
2. I felt the quality of the virtual exam was as good as the standard "hands on" flight physical.



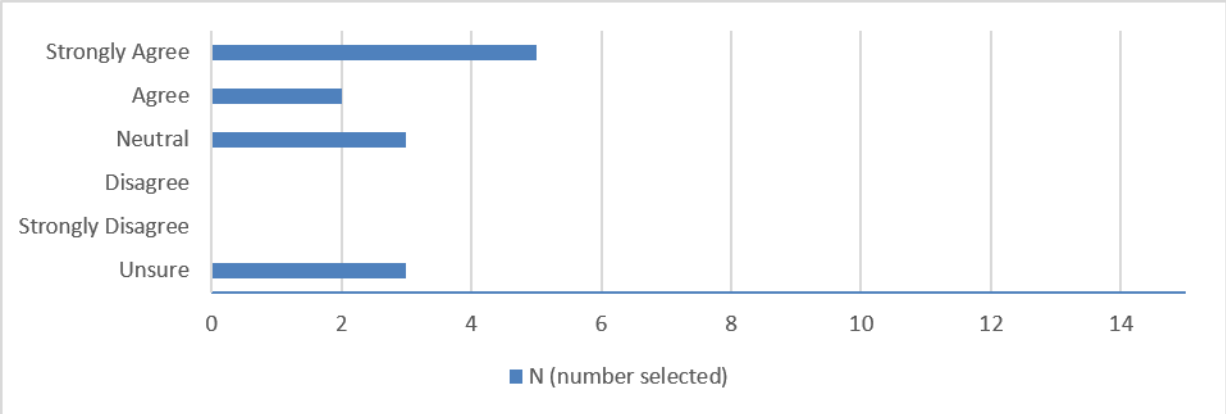
3. I felt comfortable obtaining data for the eye examination virtually.



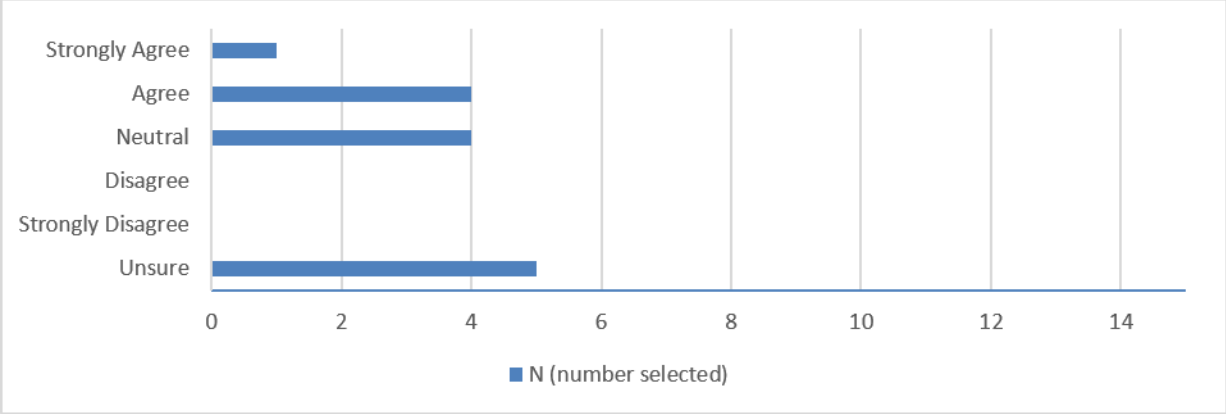
4. I felt comfortable listening to heart sounds using the virtual stethoscope.



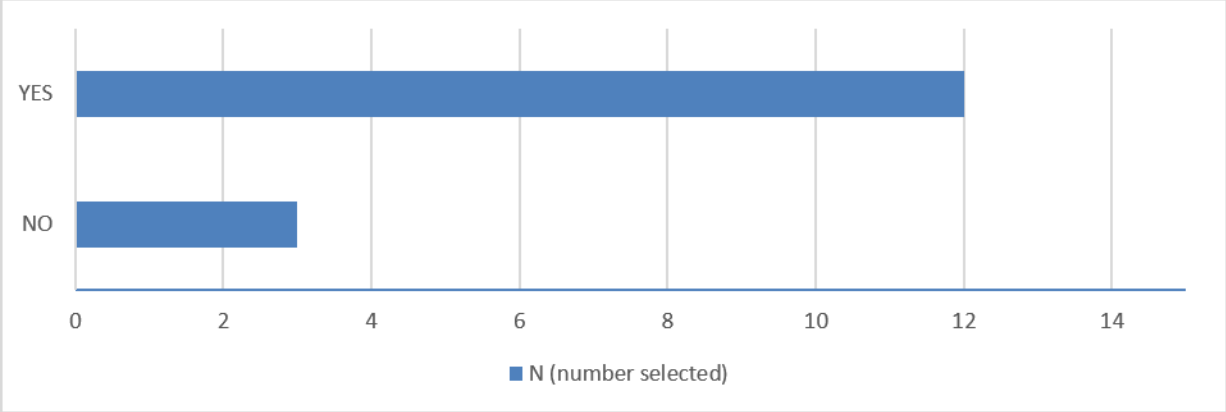
5. I felt comfortable having the patient/pilot assist with utilizing the instruments in the simulated kiosk to perform the examination.



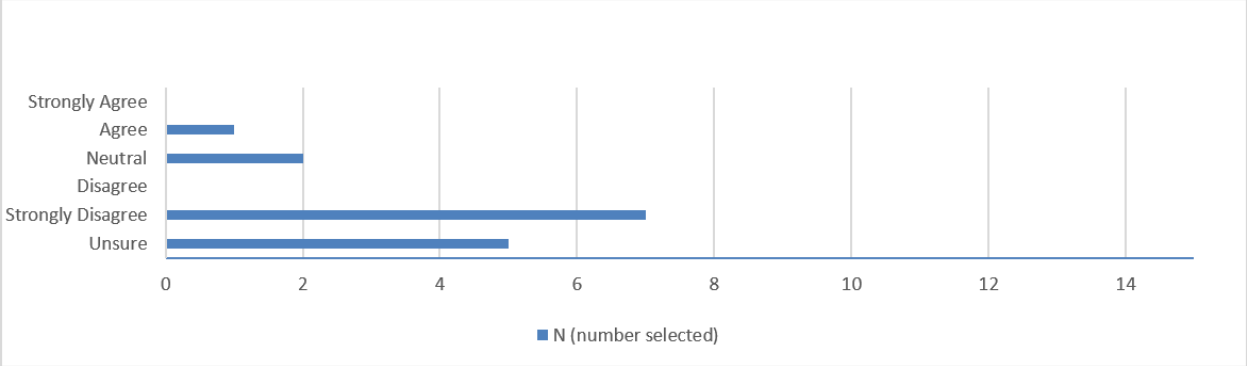
6. I felt comfortable using the mobile camera to perform the virtual examination.



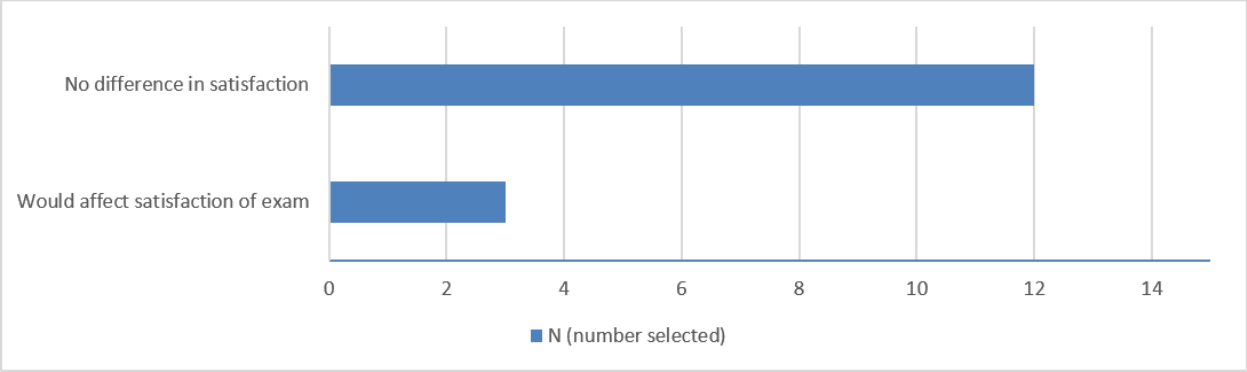
7. I asked the medical applicant to partially disrobe for a portion of the examination.



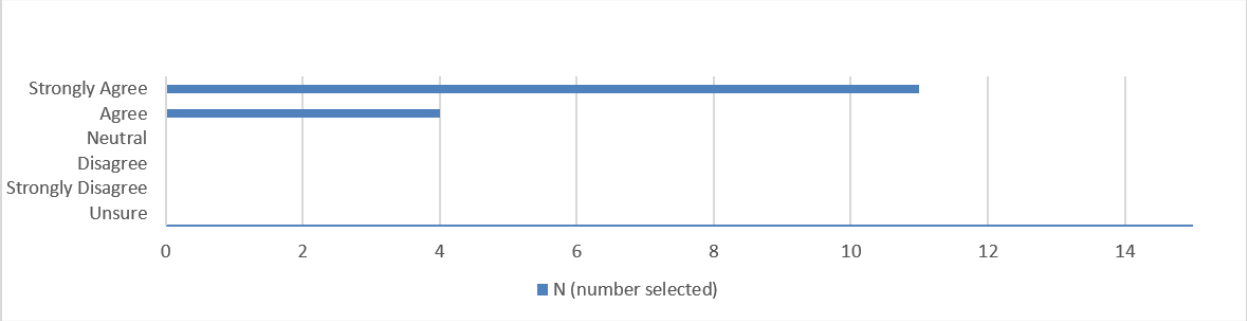
8. It felt more awkward than usual to ask the pilot to partially disrobe in a virtual setting as compared to an in-person experience.



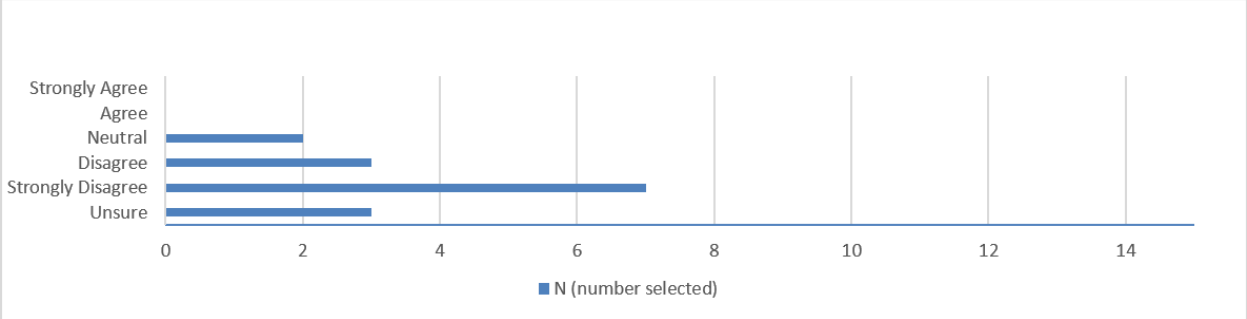
9. If a urine test and/or an electrocardiogram (ECG) had to be obtained by the pilot elsewhere prior to the virtual flight physical, how would this affect your overall satisfaction with the virtual examination experience?



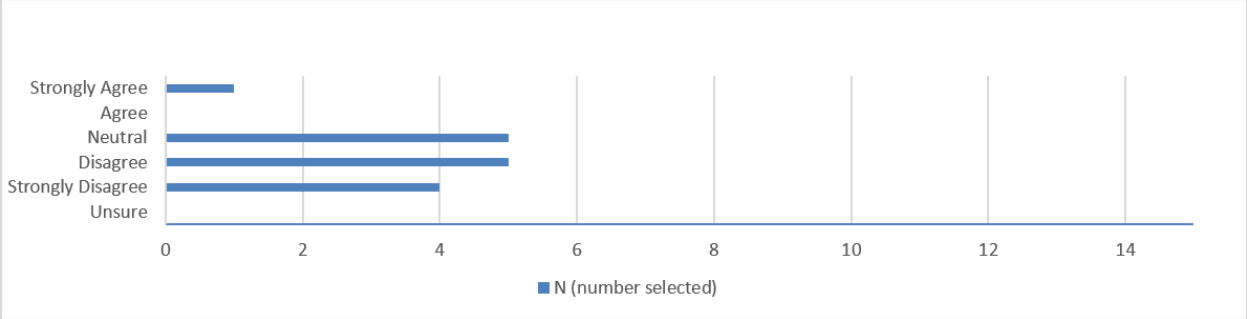
10. I felt that the security of the virtual flight physical was adequate (e.g., protected health information was actually protected).



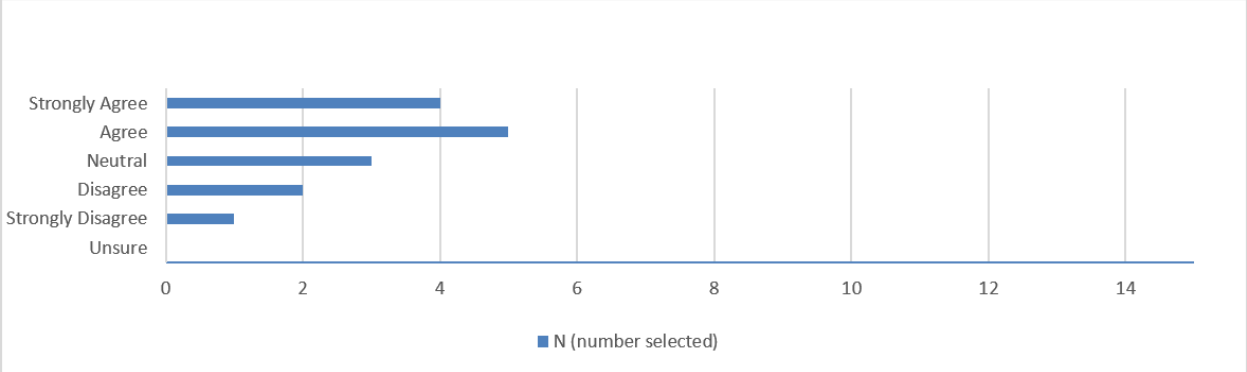
11. I felt confident that my physical examination done virtually was as good as one done through a “hands-on” experience.



12. Based on my experience, virtual flight physicals seem ready for “prime time.”



13. I would support the use of virtual flight physicals using a kiosk model in the future.



Discussion on Potential Impact Identified from Proof-of-Concept (Project #1)

1. **Improved access and convenience for pilots** - Placing kiosks in strategic areas of higher-volume locations of pilots with generally uncomplicated medical histories, such as at flight schools, or places where professional pilots congregate during downtime at airports (e.g., crew hubs), at general aviation airports, or at other targeted locations with adequate security to prevent vandalism or inappropriate access would allow pilots to self-schedule appointments and remain certified in an era where access to aviation medical examiner appointments has decreased. Study subjects had little or no trouble scheduling a date and time for the assessment using an app on a smartphone or a web-based portal.
2. **With more experience using virtual tools, the providers became more comfortable** – Since none of the participant AMEs had ever performed physical examinations remotely prior to using the kiosk model, there was initial hesitation in how best to utilize the instrumentation, and physicians indicated they were unsure about certain exam findings due to lack of experience with the technology. With experience of prior kiosk-based exams, the physicians seemed to become more comfortable. By the time the study providers had assessed several patients/pilots, asking an individual to disrobe felt normal, and most participants did not feel awkward about being examined remotely.

3. **The kiosk was not a substitute for an in-office examination** – Providers suggested that the kiosk, while a potential tool for straightforward exams, was not ready for "prime time" to replace in-person exams. Suggestions included focusing on improving technology, improving education for AMEs on how to utilize the instrumentation, such as the electronic stethoscope and otoscope, and streamlining visual acuity assessment. The study configuration also did not include the required ophthalmoscopic fundus examination; any future model would require a validated technological means of visualizing the fundus.

PHASE #2: PRELIMINARY DIAGNOSTIC PERFORMANCE STUDY USING A KIOSK MODEL FOR ASSESSING ABNORMAL PHYSICAL FINDINGS

Study Aims

1. Assess the fidelity of using a kiosk model to detect safety-sensitive physical abnormalities in a study cohort with both normal physical findings and known physical deficiencies.
2. Determine technological limitations in instrumentation and software used within a kiosk model.
3. Obtain satisfaction data from providers in performing physical examinations remotely for potential future use for aeromedical certification.
4. Study logistical differences in remote versus in-person models for obtaining aeromedical certification.

Methods and Study Design

This study conducted a retrospective review to determine whether physicians could reliably detect potentially safety-sensitive abnormal physical findings during remote/virtual exams via a kiosk model compared with an in-office visit.

A total of five (5) study participant physicians were enrolled in the study. They were required to have clinical experience evaluating patients (a minimum of three years) but would not be required to have served as AMEs or to be a current AME. The physicians had no prior experience performing physical exams using the kiosk model nor any experience performing telehealth examinations.

Prior to performing a kiosk-based examination, a physician participant was given instruction on the operation of the remote system by the study investigators and then performed a kiosk-based simulated exam with study investigators to ensure they were familiar with the controls and logistics of the remote examination system. Training sessions were hosted by the primary study investigator and study staff. Training video(s) and live virtual training were provided. After

completion of virtual exam training, participant physicians signed a training attestation sent via REDCap electronic form.

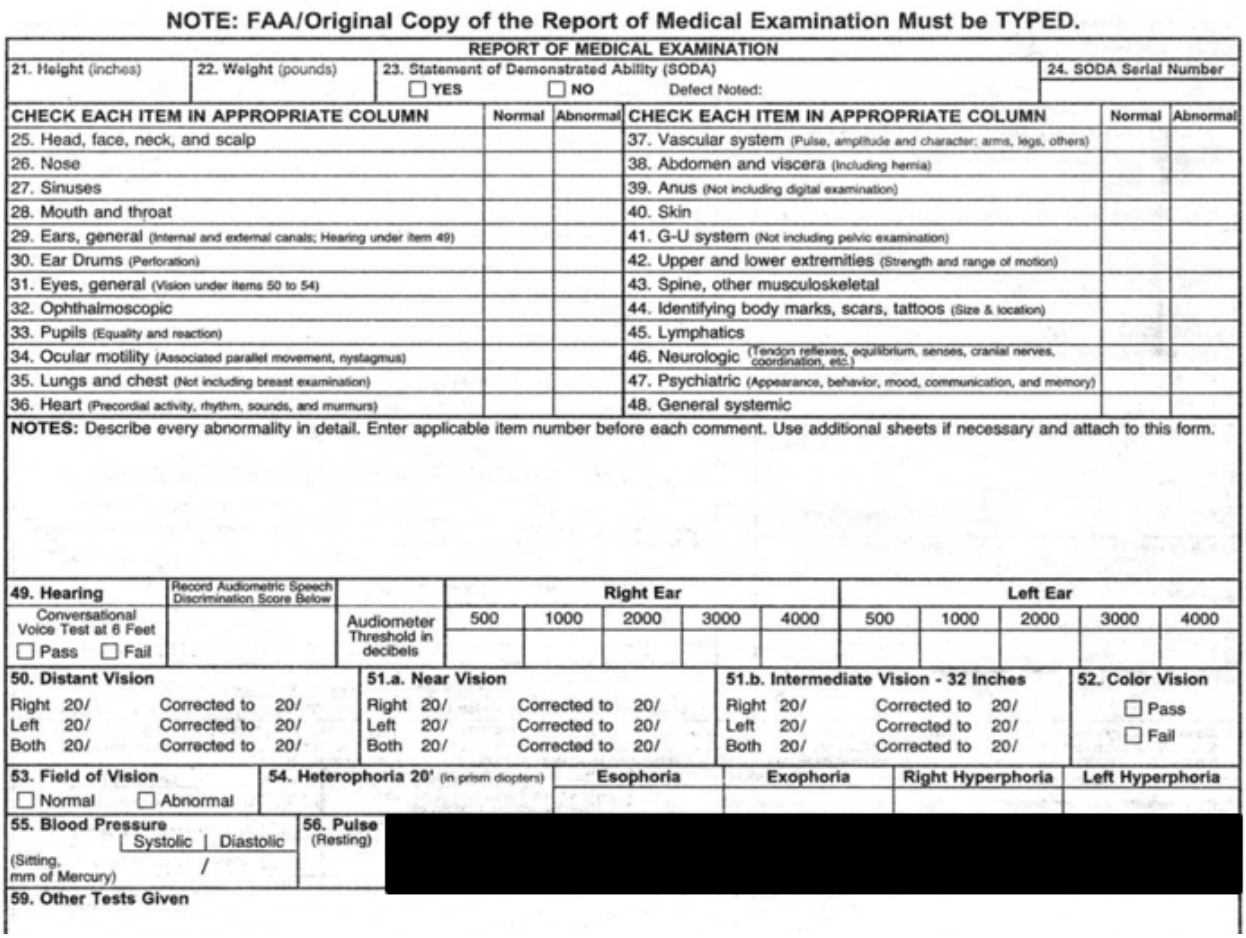
During examinations using the kiosk-based model, each physician recorded their physical findings for each patient study subject examined utilizing an electronic worksheet with data entry points similar to the FAA medical certification form (Form 8500-8; see Figure 4). After each examination, a member of the study team reviewed what was documented by the study participant physician to determine if the known physical abnormalities associated with potential safety-sensitive function were identified. The findings were also entered in a semi-quantitative scoring matrix, and a score was provided for each exam (20 possible points).

After all five participant virtual visits were completed, the study participant physician satisfaction data were collected using the REDCap survey form.

For recruitment, each physician was contacted by the study coordination team telephonically and offered an opportunity to enroll in the study. All enrolled providers received $100 remuneration for each enrolled participant visit via payroll addition or gift card upon completion of their involvement with the study, which included the required five (5) completed enrolled participant visits and all required data collection surveys. Information was collected to submit/process remuneration. One physician participant was on staff at Harvard Medical School, and the other four providers were on the clinical staff of Mayo Clinic. None of the providers had participated previously in performing telehealth examinations as part of their practices.

A total of five (5) patient participants were enrolled in the study. One “normal” participant (no known significant physical abnormalities) served as a control. The remaining four participants were recruited from various clinical areas within Mayo Clinic for scheduled clinical care (e.g., heart valve clinic in Cardiology, Ophthalmology clinic areas focused on diagnosis and treatment of cataracts, the movement disorder clinic in Neurology, etc.). Each participant was contacted by the study coordination team telephonically and offered an opportunity to enroll in the study. If willing, the patient consented verbally to participate prior to attending the research study visit(s) on the Rochester Mayo campus. The research visits were a compilation of six physical exam visits. To confirm enrolled participants’ physical findings, a retrospective chart review and in-person physical office visit were performed by a physician in the study team for visit 1. The provider performing the in-person exam as a control was not blinded to the abnormal physical findings of the study participant. An additional five (5) kiosk-based physical exam visits were then performed by five different physicians. All enrolled patient participants received ($550 total) remuneration via gift card or check at the completion of their involvement with the study. $50 remuneration was distributed at the completion of visit 1, and the completion of visits 2-6 was required for the additional $500 remuneration. For Mayo Clinic employees, research payments were included in the payroll paycheck. A parking voucher was provided when requested.

The kiosk for this study involved a computer and instrumentation set up in an existing examination room, similar to that pictured in (Figure 5), which provided a private environment to perform the required examination using electronic instrumentation attached to the kiosk unit.



NOTE: FAA/Original Copy of the Report of Medical Examination Must be TYPED.

REPORT OF MEDICAL EXAMINATION

21. Height (inches)	22. Weight (pounds)	23. Statement of Demonstrated Ability (SODA) ☐ YES ☐ NO Defect Noted:	24. SODA Serial Number

CHECK EACH ITEM IN APPROPRIATE COLUMN	Normal	Abnormal	CHECK EACH ITEM IN APPROPRIATE COLUMN	Normal	Abnormal
25. Head, face, neck, and scalp			37. Vascular system (Pulse, amplitude and character: arms, legs, others)		
26. Nose			38. Abdomen and viscera (Including hernia)		
27. Sinuses			39. Anus (Not including digital examination)		
28. Mouth and throat			40. Skin		
29. Ears, general (Internal and external canals; Hearing under item 49)			41. G-U system (Not including pelvic examination)		
30. Ear Drums (Perforation)			42. Upper and lower extremities (Strength and range of motion)		
31. Eyes, general (Vision under items 50 to 54)			43. Spine, other musculoskeletal		
32. Ophthalmoscopic			44. Identifying body marks, scars, tattoos (Size & location)		
33. Pupils (Equality and reaction)			45. Lymphatics		
34. Ocular motility (Associated parallel movement, nystagmus)			46. Neurologic (Tendon reflexes, equilibrium, senses, cranial nerves, coordination, etc.)		
35. Lungs and chest (Not including breast examination)			47. Psychiatric (Appearance, behavior, mood, communication, and memory)		
36. Heart (Precordial activity, rhythm, sounds, and murmurs)			48. General systemic		

NOTES: Describe every abnormality in detail. Enter applicable item number before each comment. Use additional sheets if necessary and attach to this form.

49. Hearing	Record Audiometric Speech Discrimination Score Below		Right Ear					Left Ear				
Conversational Voice Test at 6 Feet ☐ Pass ☐ Fail		Audiometer Threshold in decibels	500	1000	2000	3000	4000	500	1000	2000	3000	4000

50. Distant Vision	51.a. Near Vision	51.b. Intermediate Vision - 32 Inches	52. Color Vision
Right 20/ Corrected to 20/	Right 20/ Corrected to 20/	Right 20/ Corrected to 20/	☐ Pass
Left 20/ Corrected to 20/	Left 20/ Corrected to 20/	Left 20/ Corrected to 20/	☐ Fail
Both 20/ Corrected to 20/	Both 20/ Corrected to 20/	Both 20/ Corrected to 20/	

53. Field of Vision ☐ Normal ☐ Abnormal	54. Heterophoria 20' (in prism diopters)	Esophoria	Exophoria	Right Hyperphoria	Left Hyperphoria

55. Blood Pressure (Sitting, mm of Mercury) Systolic / Diastolic	56. Pulse (Resting)
/	[redacted]

59. Other Tests Given

Figure 4.

Physical findings were recorded on a form similar to the actual FAA medical certification form (Form 8500-8).

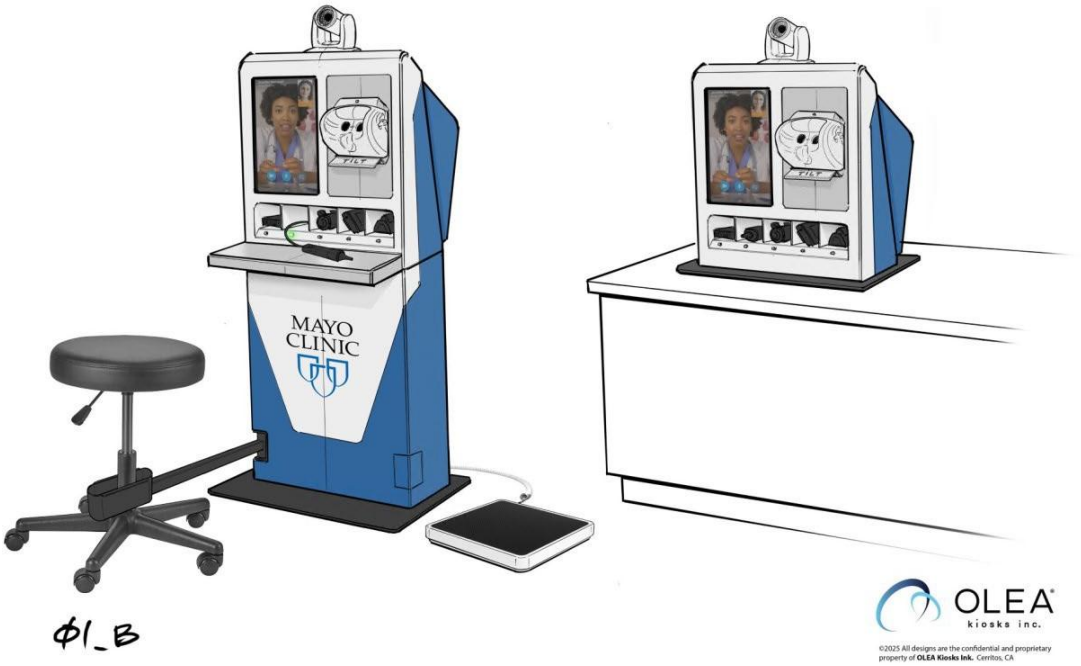


Figure 5.
The kiosk contained technology to perform remote examinations in a secure and confidential environment.

This was a prospective study, with participants screened by using a clinical list from various specialty clinics within Mayo Clinic (e.g., heart valve clinic in Cardiology, Ophthalmology clinic areas focused on diagnosis and treatment of cataracts, the movement disorder clinic in Neurology, etc.). The Mayo Clinic Electronic Medical Record System/EPIC (EMR) was utilized to verify patient participant acknowledgment to participate in research, review retrospective patient participant medical information for research study purposes, and document research note(s) and annotations.

- Physical findings were recorded similar to the data on the actual FAA medical certification form (Figure 4).
- Physical data detailed under study procedures were collected from participants using the kiosk system, with patient participants signing a HIPAA Authorization to Use and Disclose Protected Health Information document. Personal Health Information included name, date of examination, phone number, email address, street address, city, state, zip code, time zone, date of birth, and Social Security number. This information was used to provide remuneration to subjects.
- Physical finding worksheets were analyzed to determine if the provider identified the known physical abnormalities associated with potential safety-sensitive function (major findings) or non-critical physical findings not associated with potential safety-sensitive function (minor findings).

Patient Inclusion Criteria:

- Any Mayo Clinic patient aged 18-85 years with a known physical deficiency that could be extrapolated to be a safety-sensitive finding if that individual was a pilot (study subjects would be recruited for specific known abnormalities such as a heart murmur, cataract, movement disorder, etc. or to serve as a normal control).
- Availability to participate in multiple in-person and/or multiple physical examinations in an office on the Mayo Clinic campus by five different physicians performing the examination remotely, with some examinations occurring on the same day by different physician study participants.

Patient Exclusion Criteria:

- Patients with visual or auditory acuity abnormalities that would preclude them from communicating with a provider remotely via a computer monitor.
- Inability to read or speak English.
- Immobility that would require assistance from another individual
- Inability to operate a smartphone or use online applications

Target Physician screening:

Medical providers were enrolled from Mayo Clinic staff directory listings or a designated licensed physician(s) by the study Principal Investigator.

Physician Inclusion Criteria:

A provider must have had clinical experience evaluating patients but would not be required to have served as an aviation medical examiner or to be a current AME. Participants as a provider must have had at least three years of clinical experience after graduation from medical school.

Physician Exclusion Criteria:

A healthcare provider who had insufficient experience or was not willing or comfortable using the computer technology.

Provider Consent Visit:

Providers were contacted by the study team or coordinator via telephone, explaining their eligibility to participate in the research study. If the provider agreed to enroll in the study, they were verbally consented. A HIPAA document was not required as no private healthcare information was collected. The enrolled provider's verbal consent was documented in the study binder, and the physicians were scheduled for study visits. Physician information was collected to submit/process remuneration.

Enrolled participants (patient/physician) study visit logistics:

1. **In-person visit 1**: All enrolled patient participants arrived at the Division of Public Health, Infectious Diseases and Occupational Medicine area to complete an in-person physical exam performed by a physician in the study team.
2. **Kiosk exam visit(s) 2-6**: All enrolled patient participants reported to the Division of Public Health, Infectious Diseases and Occupational Medicine area at the designated date/time and were shown to the clinical room where the kiosk-based model was set up.
3. Enrolled patient participant measurements were obtained
    - Vital signs –Blood Pressure (bp), Heart Rate (pulse) [Wellvi]
    - Vision testing acuity – distant, near, intermediate [Waggoner flatscreen visual acuity]
    - Color vision testing [on monitor using Waggoner]
    - Field of vision [visual confrontation from monitor lights]
    - Hearing – 6 ft conversational voice
    - Urinalysis – the required urine-dip result was obtained by the Mayo Clinic laboratory as part of the standard in-person flight physical, consistent with CLIA requirements. The result was displayed to the remote examiner through a shared screen or patient portal and recorded by the examiner; urinalysis was not performed through the kiosk.
4. Enrolled Physician performed a remote exam and reviewed history, medications, etc. with study participant (Figure 6).
5. Enrolled patient participant physical exam – the patient participant disrobed as requested by the physician
    - Head, Ears, Nose, and Throat exam (ENT), Eyes, Ears (with electronic otoscope); an ophthalmoscopic fundus examination was not performed.
    - Skin (identifying body marks, scars, tattoos)
    - Heart (with electronic stethoscope)
    - Lungs (with electronic stethoscope)
    - Extremities
    - Neurological / Musculoskeletal
    - Mental Status (routine observational component only; no structured psychiatric assessment or evaluation of a known mental health condition was performed)
    - General (record obesity, etc.)
    - A virtual acuity eye screening exam was performed by an authorized evaluator, including a trained member of the research study team.
6. Survey/Data Collection

a. Enrolled patient participant physical findings were recorded by the enrolled participant provider on a study REDCap survey using methods similar to those obtained during an FAA flight physical.

b. After each examination, the enrolled participant physicians completed a follow-up assessment survey using the Mayo Clinic licensed REDCap survey tool focused on satisfaction with logistics, ability to perform the examination seamlessly, and value-add to a clinical practice.

c. Enrolled patient participant filled out post exam feedback survey(s), data collection using study REDCap survey methods

7. Steps 2-6 were completed repeatedly in 5 different cycles; each enrolled patient participant was examined virtually by 5 different enrolled participant physicians.

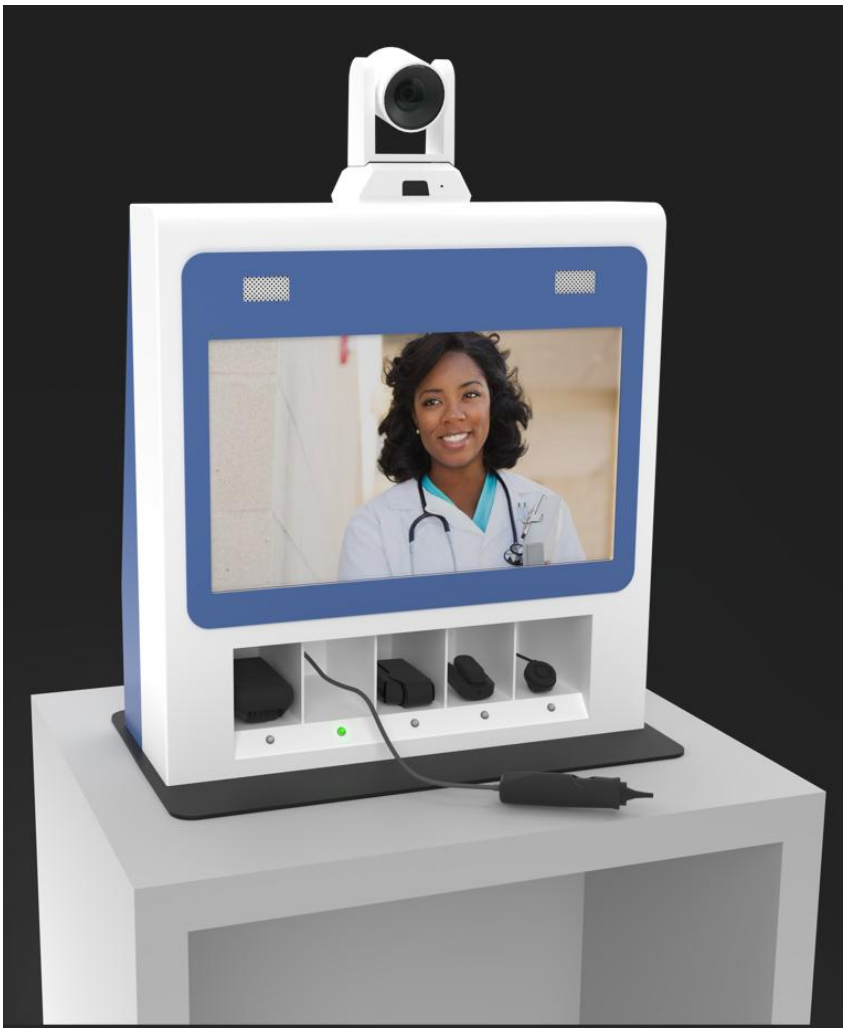


Figure 6.
The updated kiosk contained technology to perform remote examinations in a secure environment similar to that pictured in this figure.

Data Analysis

1. Physical finding worksheets recorded electronically were analyzed to determine if the provider identified the known physical abnormalities associated with potential safety-sensitive function and any non-critical physical findings not associated with potential safety-sensitive function.
2. Physical findings data were recorded similarly to data in the actual FAA medical certification form (Form 8500-8) as shown in Figure 4.
3. In addition to the determination of correct identification of potentially safety-sensitive physical abnormalities in order to calculate diagnostic efficacy, a scaled score matrix (Table 3) was also developed as a semi-quantitative method to assess how well physical findings that were known to be present in the in-office setting could be identified remotely using a kiosk model (20 points maximum per patient).

Table 3.
Matrix Score Legend (20 points possible)

10 points	Identify primary safety-sensitive finding [or note no finding on control subject(s) without known abnormal physical findings]
3 points	Identify abnormalities that are not necessarily safety-sensitive (i.e., HTN, correctable visual acuity issue from testing, etc.) from history or on primary physical exam
2 points	Identify cerumen, TM scarring, or other issues identified using electronic otoscope
2 points	Identify abnormalities using electronic stethoscope
1 point each	Identify scars, tattoo(s), or birthmarks
-2 points	Listed physical abnormality when one did not exist

1. Satisfaction data from enrolled physicians were then obtained regarding performing remote kiosk-based physical examinations.
2. Satisfaction data from enrolled participants were obtained to better understand patient perceptions and satisfaction.
3. Enrollees consented that information collected as part of this study, after removal of identifiers, could be used for future research studies or distributed to another investigator for future research studies without additional informed consent.

Results

Table 4 outlines the demographics of enrolled patient participants, including what was considered a safety-sensitive finding. These included conditions such as cataracts with visual acuity deficits, posterior pharyngeal crowding observed in a high prevalence of patients with sleep-related disordered breathing, neuromuscular abnormalities such as inability to squat and return to a standing position or significant weakness of an extremity, diabetes, valvular heart murmurs, and midline sternotomy scars from recent coronary revascularization. Examples of secondary findings included prior surgical scars, identifying body marks or tattoos, glucose monitoring devices placed on extremities, kyphosis/spinal deformation, skin lesions, and centripetal obesity.

Table 5 summarizes the detection of potentially safety-sensitive physical abnormalities by each physician and stratifies using a binomial variable (YES/NO) whether the known abnormal physical finding was detected when the finding was actually present versus when the known abnormal finding was not identified while using the kiosk-based model (and vice versa). From these results, calculations of sensitivity (88%), specificity (100%), positive predictive value (100%), and negative predictive value (62.5%) were made.

The semi-quantitative matrix scores are summarized in Table 6. The overall matrix score for all providers combined was 15.72/20. There was individual variation in provider performance, but all findings were detected correctly in the normal patient control, and the vast majority of safety-sensitive findings were identified correctly by physicians utilizing the kiosk-based model.

Survey results are included in Figure 7 (patients) and Figure 8 (physicians).

Table 4.
Demographics and descriptions of safety-sensitive findings in study subjects

	Age (yrs)	Sex	Safety-sensitive conditions	Other findings
Subject #1	64	F	Bilateral cataracts, Mallampati IV/IV (risk for OSA), partial squat only with reduced knee and hip ROM, anxiety history on SSRI	Centripetal obesity, diabetes, kyphosis, laparoscopic cholecystectomy scar, umbilical hernia repair scar, multiple seborrheic keratoses on back, basal cell skin cancer resection scar right side of abdomen.
Subject #2	56	M	Charcot-Marie-Tooth syndrome with significant atrophy of the lower extremities bilaterally as well as weakness of the	Bilateral conjunctival erythema; bilateral tinea onychomycosis; forked 6 cm scars involving the right foot from triple arthrodesis; 9 cm and lateral 6 cm scar on left foot from arthrodesis.

	Age (yrs)	Sex	Safety-sensitive conditions	Other findings
			interosseous muscles of the hands bilaterally. Significant weakness (0-1/5) in extension of the feet bilaterally. Atrophied thenar eminence bilaterally with mild flexion contractures; 21.5 cm midline abdominal scar from prior resection of carcinoid tumor with mild facial flushing.	
Subject #3	76	M	**Assessable using the study kiosk configuration**: 15-cm midline sternotomy scar and two subxiphoid drain scars associated with coronary artery bypass grafting six months previously. **Known from the control examination but not assessable using the study kiosk configuration**: Bilateral abnormal optic nerves associated with glaucoma and mild retinal changes. The kiosk protocol did not include the ophthalmoscopic fundus examination	Oblique scar across right side of nose from prior prop strike; bilateral lower extremity varicosities with mild stasis changes; 9 cm right lower quadrant appendectomy scar with 2 small oblique drain scars noted inferior to this (peritonitis associated with appendectomy); Tiny skin tag in the left axillary region; acneiform lesions on buttocks; very subtle superficial scar measuring 3 cm across the volar aspect of the right wrist; small blister like lesion involving the left lower deltoid as well as ventral aspect of the right forearm. Boutonniere deformity involving multiple digits of both hands with mild flexion contractures. 14 cm vertical scar over left knee (total knee arthroplasty); 16 cm vertical scar over right knee (total knee arthroplasty). 16 cm scar from

	Age (yrs)	Sex	Safety-sensitive conditions	Other findings
			needed to evaluate these findings.*	right total hip arthroplasty with 14-cm scar down the lateral aspect of the left thigh. Right olecranon superficial abrasion scar; 4-5 cm vertical lumbar laminectomy scars Bilateral hyporeflexia at the patellar regions; bilateral tinea onychomycosis
Subject #4	65	M	Severe mitral regurgitation murmur (3/6 holosystolic); midline sternotomy scar (24 cm);	Healed scars from 32 stitches along right temporal area from laceration at age 17; Significant wax in external auditory canals; minor varicosities in lower extremities; dermatoheliosis and cherry angiomas with benign-appearing nevi on trunk and extremities, some SKs on trunk and shoulders; papules along superior periorbital skin; L knee vertical scar from ACL reconstruction; 2 cm periumbilical scar; R thoracic area prior osteomyelitis in 7th grade w lateral drain scar.
Subject #5	39	M	None	Scars on the tympanic membranes bilaterally from prior myringotomies as a child; scattered congenital nevi on the back; superficial scar across the ventral aspect of the right forearm.

*The glaucoma-related optic nerve abnormalities were established through the control examination or existing clinical information. Because the kiosk protocol did not include ophthalmoscopic fundus visualization, these abnormalities could not be evaluated during the remote examinations and were analyzed separately from kiosk-assessable findings.

Table 5.

Determination of Safety-Sensitive Finding (Item detected/Safety-Sensitive Finding Present)

	Provider 1	Provider 2	Provider 3	Provider 4	Provider 5
Subject #1	**Identified**	**Identified**	**Identified**	**Not identified**	**Identified**
Subject #2	**Not identified**	**Identified**	**Identified**	**Identified**	**Not identified**
Subject #3	**Identified**	**Identified**	**Identified**	**Identified**	**Identified**
Subject #4	**Identified**	**Identified**	**Identified**	**Identified**	**Identified**
Subject #5	**Identified**	**Identified**	**Identified**	**Identified**	**Identified**

Table 5 Legend:

Identified Safety-sensitive finding identified with kiosk model when finding was actually present (or no finding reported when safety-sensitive finding did not exist)

Not identified Safety-sensitive finding not identified with kiosk model when finding was actually present

Sensitivity = 85%
Specificity = 100%
Positive Predictive Value = 100%
Negative Predictive Value = 62.5%
Accuracy = 88%
** - pooled data used for calculations

Table 6.

Semi-Quantitative Scaled Matrix Score (20 points per patient maximum)

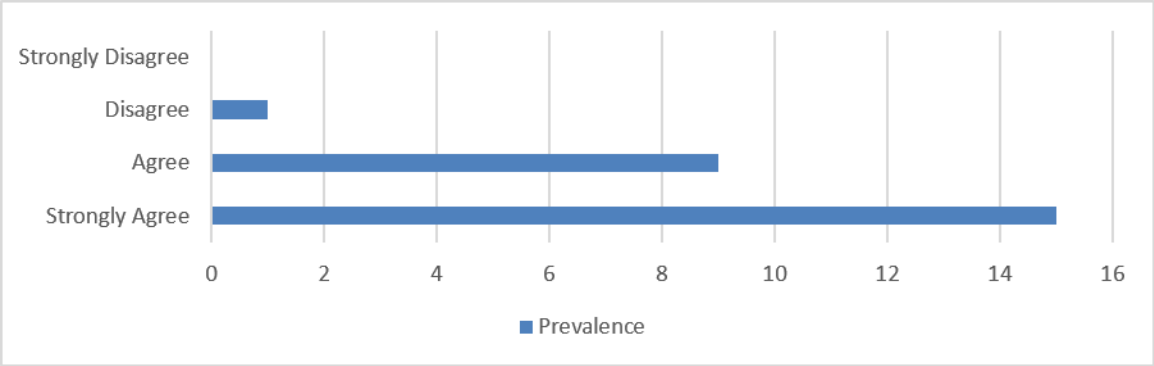
	Provider 1	Provider 2	Provider 3	Provider 4	Provider 5	Mean score
Subject #1	18	20	12	10	16	**15.2**
Subject #2	8	19	16	13‡	9	**13.0**
Subject #3	17	20	14	13	18	**16.4**
Subject #4	18	18	12	12	16	**15.2**
Subject #5	19	20	18	18	19	**18.8**
Mean Score	**16.0**	**19.4**	**14.4**	**13.2**	**15.6**	

Table 6 Legend:

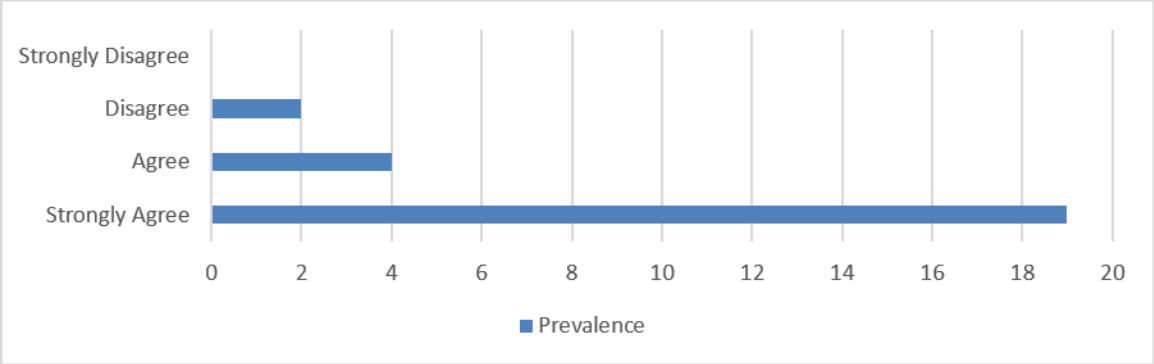
‡ = Part of session repeated due to computer connection issue
Mean Scaled Score Across Providers: 15.72/20

Figure 7.
Patient Participant Survey Data from Preliminary Diagnostic Performance Study

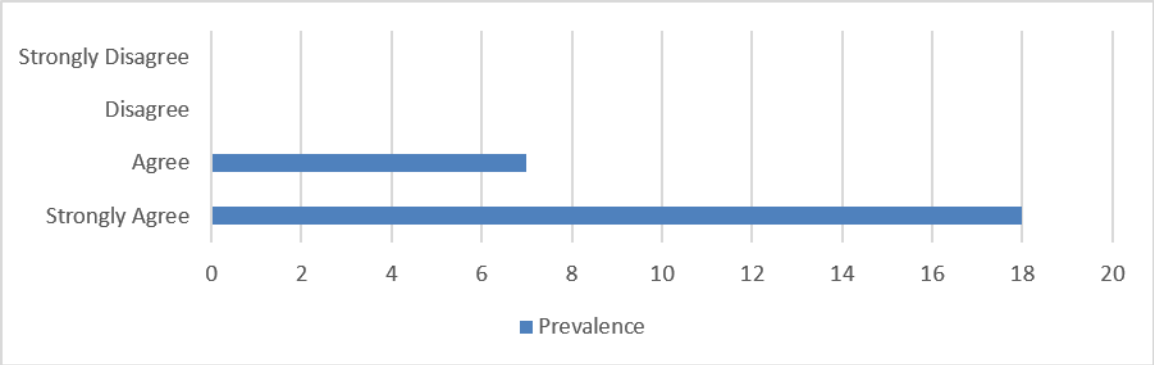
1. Logging into the system was easy.



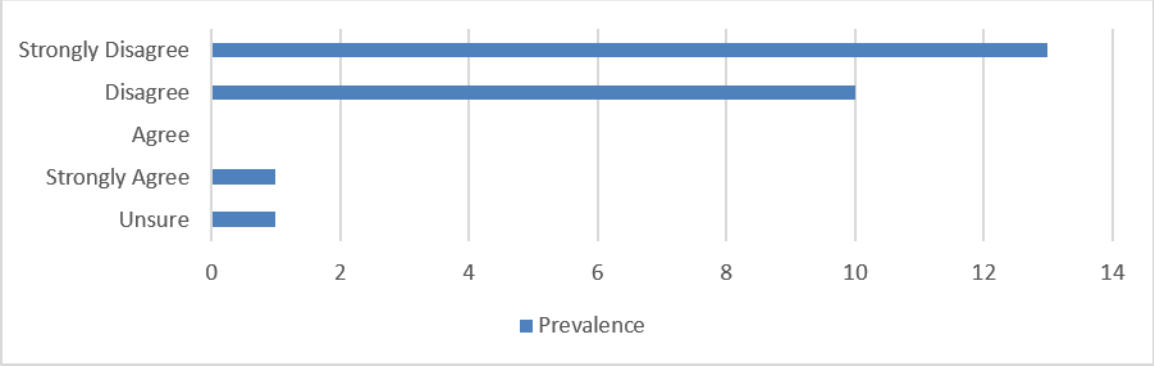
2. I had a sense that the quality of the virtual exam was as good as the standard “hands on” examination.



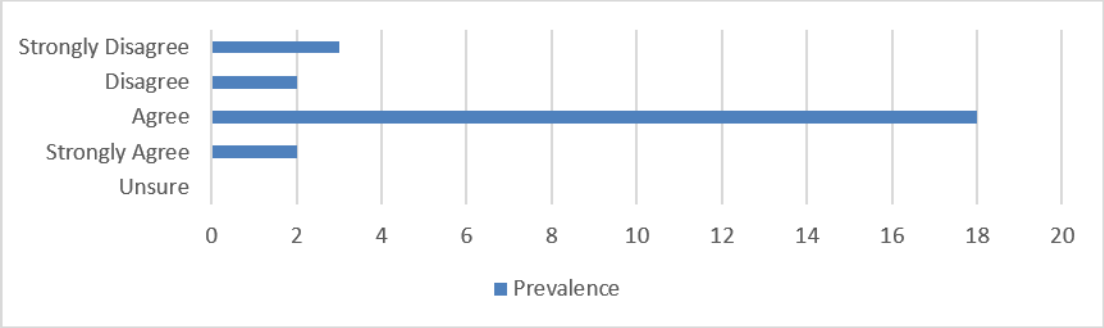
3. I felt comfortable utilizing the instruments in the simulated kiosk to perform the examination with the provider.



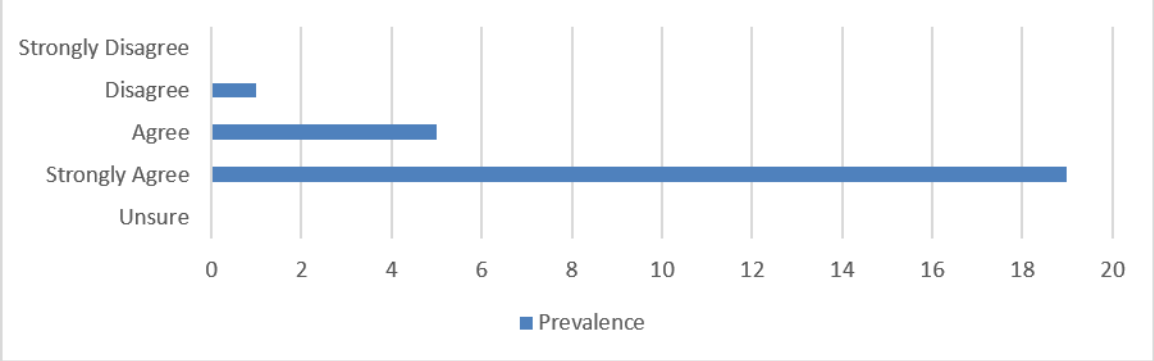
4. It felt awkward having to disrobe in the examination room/simulated kiosk for that portion of the physical exam.



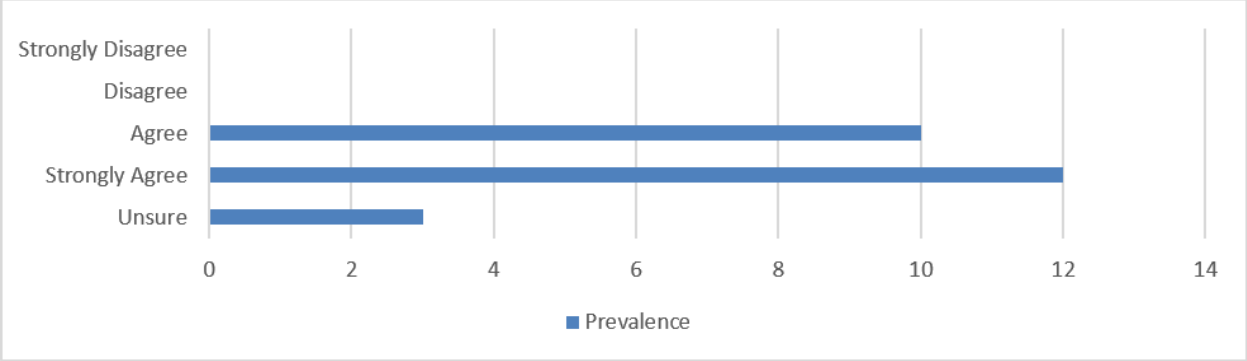
5. I felt that using a virtual system is as good as an in-person physical examination.



6. I felt giving a medical history was just as easy as in-person using the virtual system.



7. I felt the security of the virtual physical was adequate (e.g., protected health information was actually protected).



8. I would be willing to pay for a remote physical kiosk exam experience if I had a medical condition that needed follow-up, such as a certification exam.

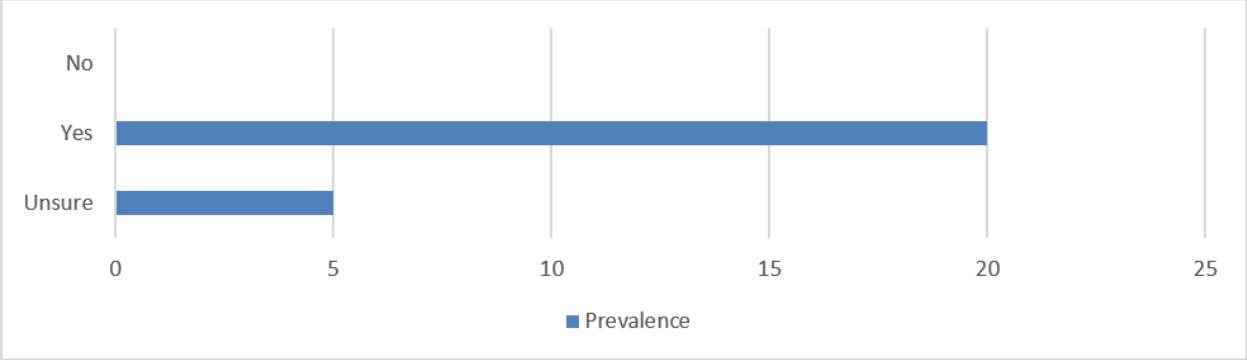
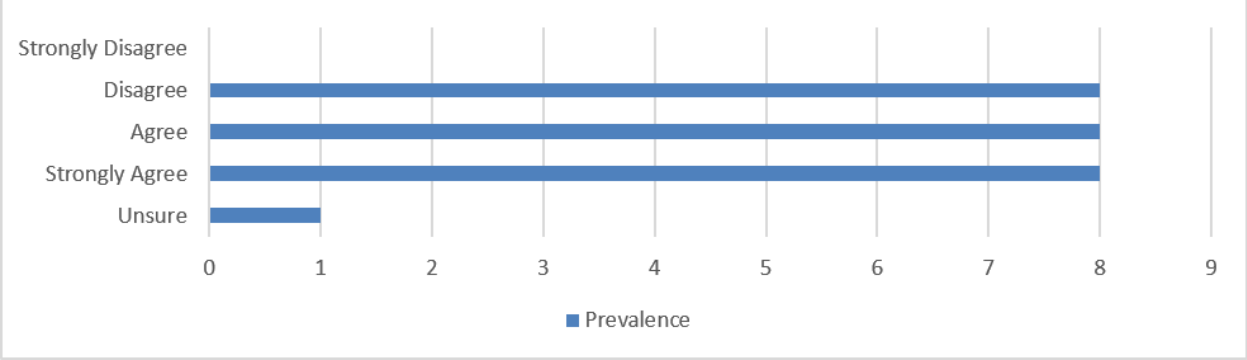
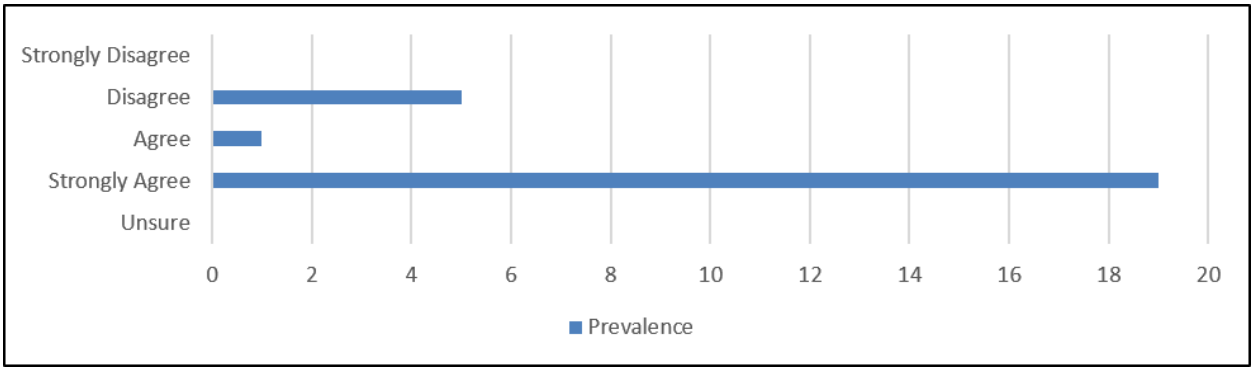


Figure 8.
Physician Participant Survey Data from Preliminary Diagnostic Performance Study

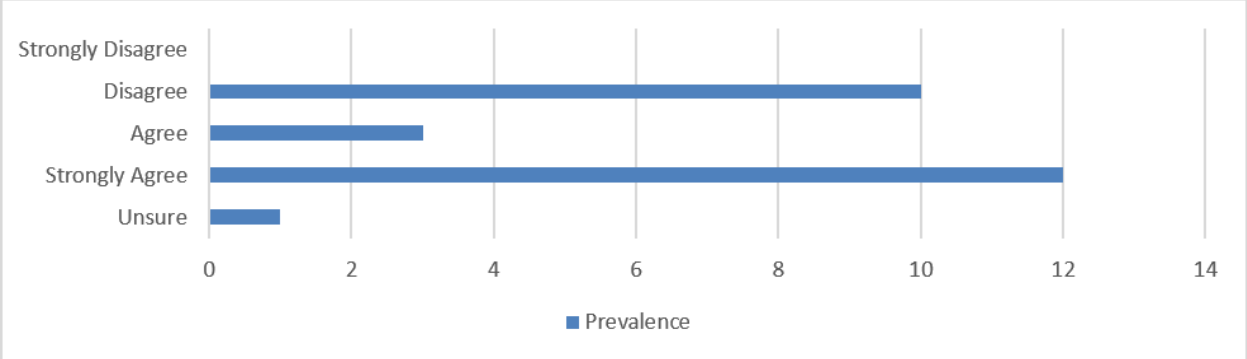
1. I had no difficulty in learning the basic use of the instruments and camera for the virtual physicals.



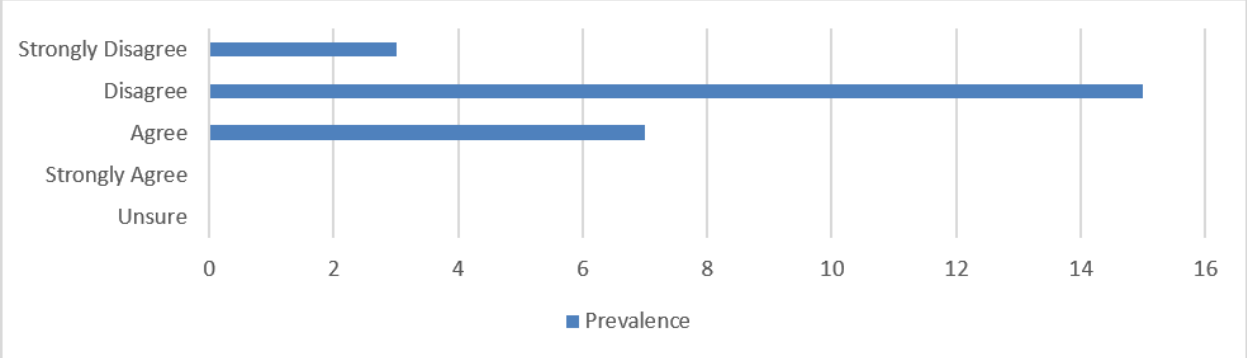
2. Logging onto the system was easy.



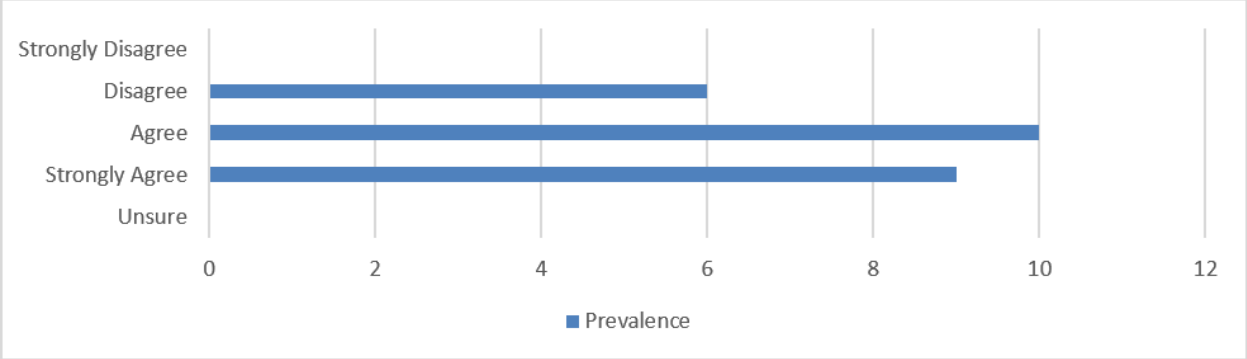
3. I was able to perform the physical exams without interruption from technical glitches.



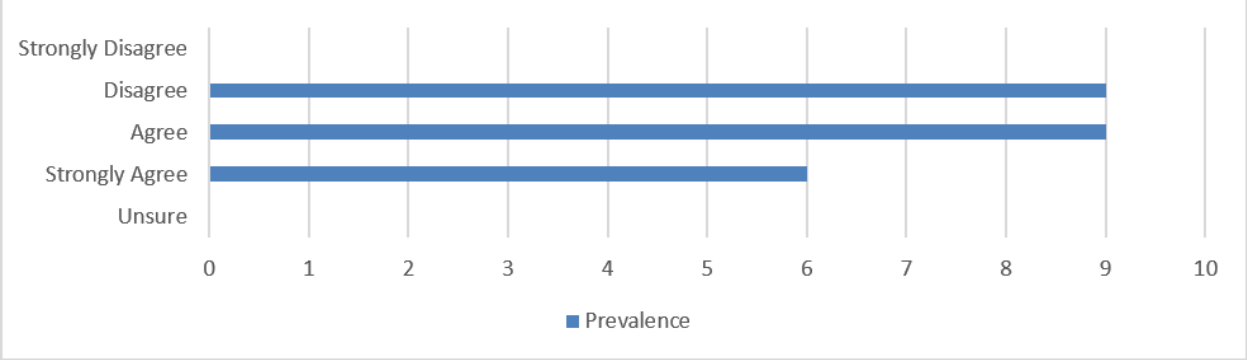
4. I had a sense that the quality of the virtual exam was as good as the standard “hands on” examination.



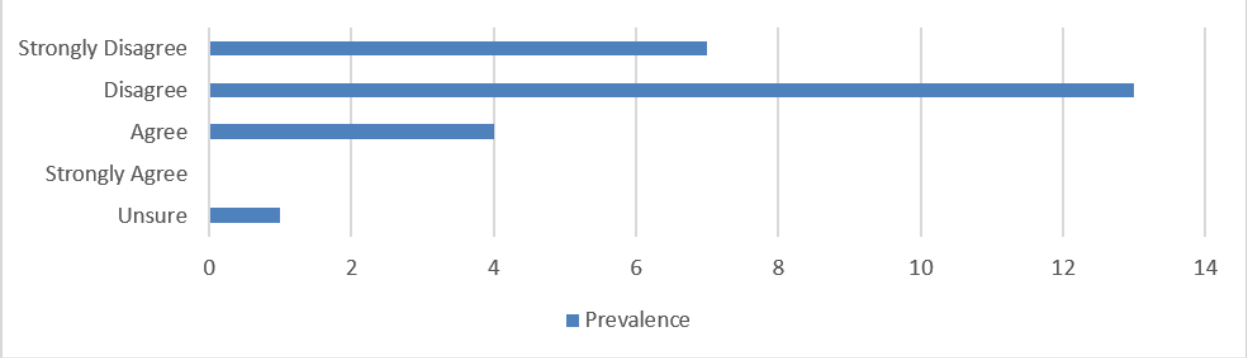
5. I felt comfortable obtaining data for the physical examination virtually.



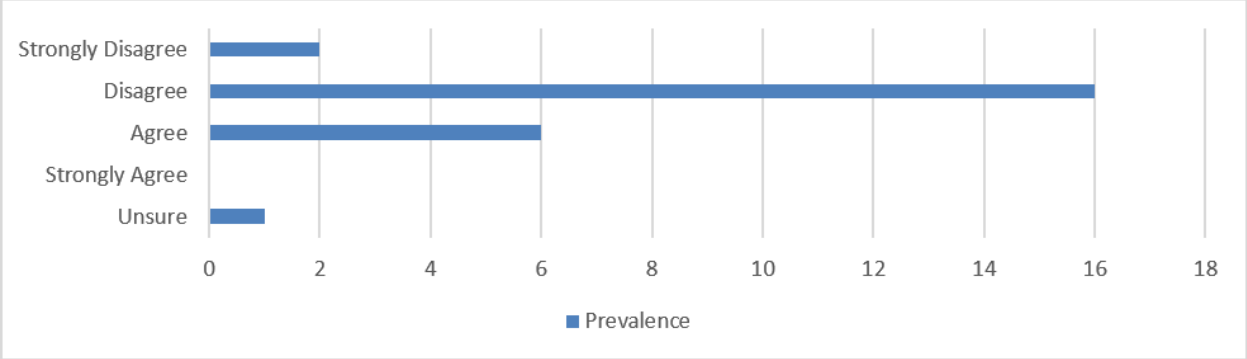
6. I felt comfortable utilizing the instruments in the simulated kiosk for performing the examination.



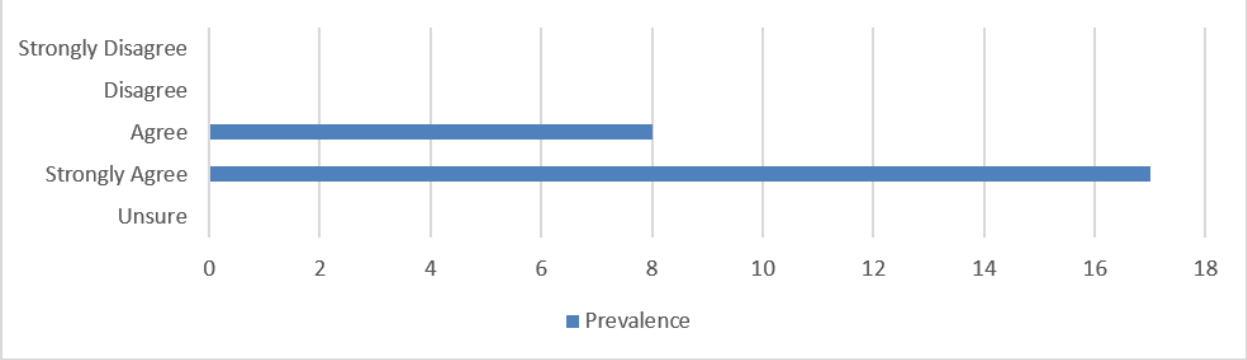
7. It felt awkward to have the patient applicant disrobe in the examination room/simulated kiosk for that portion of the physical exam.



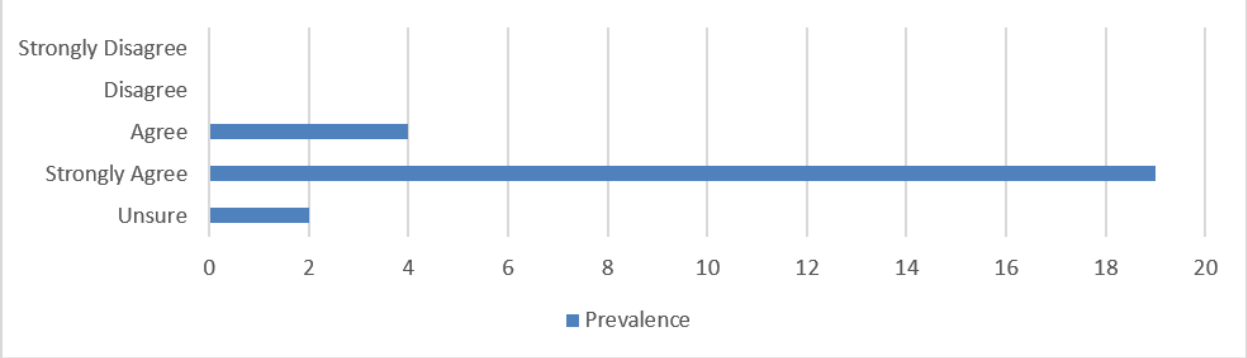
8. Using a virtual system is as good as an in-person physical examination.



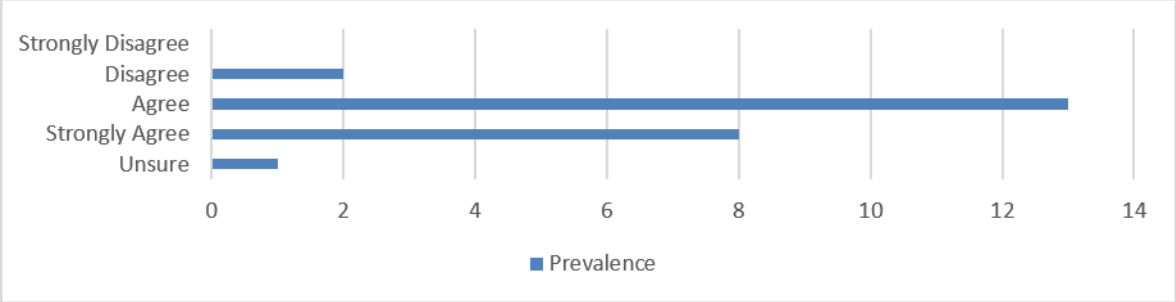
9. I felt that history taking with the patient was just as easy as in-person using the virtual system.



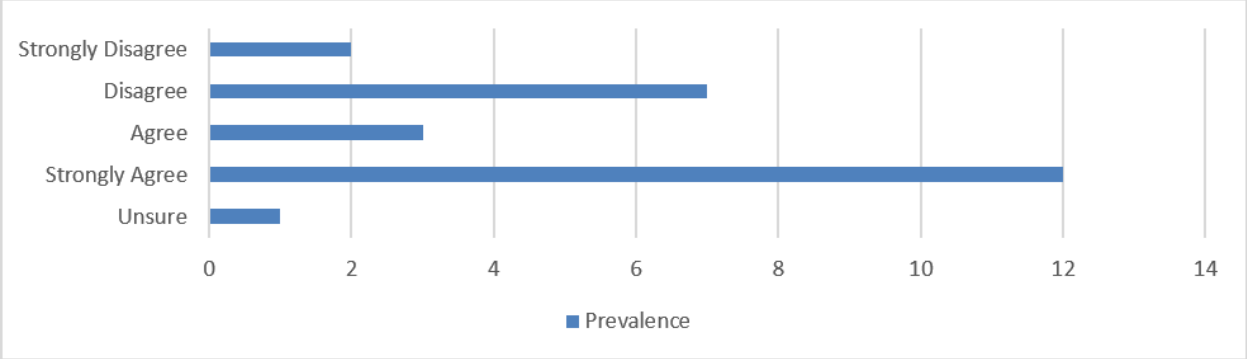
10. The security of the virtual flight physical was adequate (e.g., protected health information was actually protected).



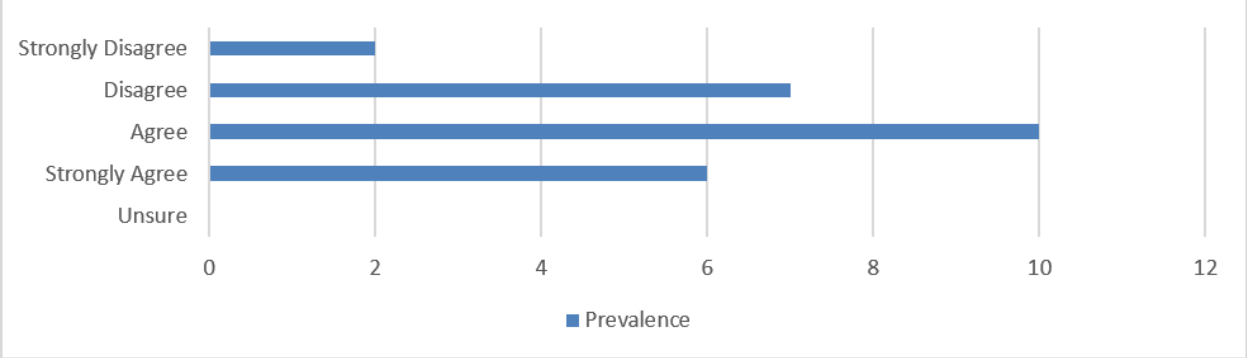
11. I am more comfortable performing a physical examination through a “hands-on” experience.



12. I would be comfortable working in an environment where I can perform remote exams for compensation similar to in-person exams.



13. I am not sure that a remote physical examination is ready for “prime time."



DISCUSSION

Although models for conducting medical interviews and confirming medical histories have been used extensively in the past decade, performance of physical examinations remotely for regulatory/certification purposes is rare or non-existent, particularly for safety-sensitive activities such as aeromedical certification, commercial driving, or maritime operations. This preliminary diagnostic performance project was designed to be a preliminary analysis of performing a non-inferiority study for FAA aeromedical certification purposes as the next step in data-driven research. Perceptions of patients undergoing remote examinations indicated that logging on to the software system, information security protection, and the value of a remote exam were favorable, even if remote examinations were recorded and stored digitally. Similarly, there did not appear to be significant concern regarding disrobing in front of a computer monitor or manipulating the instrumentation for the physician performing the remote exam. However, physicians viewed the technology skeptically and felt that an in-office exam was likely more accurate and of higher quality than remote examinations. Despite this perception, the kiosk-based model appeared to be associated with a sensitivity of 88% and a positive predictive value of 100% (total accuracy of 90%). And while the kiosk-based model was not designed to replace an in-person office examination, for certain subsets of medical applicants such as those with no known medical issues, the pre-test probability for a cohort of otherwise healthy individuals could allow for regulatory utility. Given rapid technology improvements, the ability to perform an examination for regulatory purposes remotely provides convenience for the individual being examined, potentially improved access in geographic regions where there is a dearth of AME physicians, and could allow AMEs who are interested in working remotely to do so on a part-time basis if appropriately licensed, credentialed, and educated on how to utilize the instrumentation associated with a kiosk -based examination model.

Strengths

Use of kiosk-based technology continues to evolve and improve rapidly. The simulated kiosk used in Project #1 (proof-of-concept), despite being rather rudimentary, still seemed to be easy to use per the AMEs and the pilots undergoing exams, provided perceived value to the pilot user, and included technology that allowed physicians to identify physical abnormalities that would be considered potentially safety–sensitive, even in a selected cohort of patients with underlying complex conditions as noted in Project #2. These physical abnormalities included cataracts, a severe mitral regurgitation murmur, and atrophy and neuromuscular weakness in an individual with Charcot-Marie-Tooth syndrome. Importantly, in the control participant in Project #2, all of the providers were able to identify correctly that there were no physical abnormalities and also identified all of the secondary physical findings that were not safety-sensitive. The technology could potentially allow AMEs to perform examinations remotely either from their residence or in a medical office setting for pilots who may be geographically remote and have limited access to flight physicians closer to home. Also, AMEs with significant experience who are considering retirement or who have retired recently could theoretically continue to serve as an AME either full-time or part-time, performing flight physicals remotely. If future adequately powered studies demonstrate non-inferior performance and an acceptable level of safety,

remote examinations could allow the FAA to develop a backup plan to an in-person visit should another national public health emergency arise, such as the COVID-19 pandemic. Kiosks would be outfitted with standard instrumentation, regularly maintained to ensure appropriate fidelity and quality, and, as with any system, would require appropriate credentialing, education, and training for AME physicians to utilize the remote examination model. Use of the technology would also allow the FAA to perform quality assessment initiatives since all examinations would be saved digitally and could be accessed for QA purposes at a future date.

Weaknesses

Regulatory/certification exams have not previously been administered using telehealth technology. Unlike current platforms used for virtual meetings, performance of a regulatory examination requires use of electronic instrumentation, high-definition cameras, and other devices in order to obtain vital signs, visual acuity, and other data critical for making a certification determination. Software development and coordination of a standardized system for achieving this vision remain in the research phase, and as opined by the majority of providers serving as participants in each of the projects outlined in this report, the current system is not yet ready for "prime time." These particular projects are considered preliminary without adequate sample size to make wide-ranging claims about efficacy or accuracy. Preliminary calculations of diagnostic fidelity are plagued by small sample sizes and should be viewed cautiously. However, the preliminary observations from these studies are hypothesis-generating and suggest that further research is warranted to validate this examination platform within a regulatory environment.

Generalizability

Data from these preliminary studies suffer from low total enrollment numbers and require larger data sets in order to establish more compelling conclusions. However, the preliminary data indicate that remote kiosk-based technology is possible, and with improved technological development, refined logistics, and additional investment, it has the potential to serve as an alternative to the traditional in-person office visit in the future.

Implementation Barriers

Any new technology comes with implementation challenges. Private-sector software developers, kiosk manufacturers, and device creators hesitate to invest in products or systems within the regulatory environment if the regulator does not specifically endorse it or encourage development. Aeromedical certification has used an in-person model for more than a century, so transitioning to alternative models may be met with challenges not only from the FAA in terms of policy development but also from AME physicians performing the examinations. As outlined previously, the purpose of the kiosk-based model is not to replace the traditional in-office setting, but to instead identify a subset of medical applicants who may benefit from this certification model, and in times of public emergency, allow for equivalent levels of safety in preserving the medical examination as part of the human factor in aerospace operations. Even if embraced by the FAA, there may be regulatory barriers in terms of medical licensing (if certain states determine flight physicals as involving the actual practice of medicine rather than AMEs simply

providing information or establishing a regulatory pathway rather than practicing medicine, or through international policy [e.g., if a pilot is certified using a technology that is not necessarily ICAO approved, will the certificate remain valid outside the borders of the U.S.?]).

Economic Implications

The cost of kiosk development, software development, AME recruitment, as well as credentialing and training, are all factors that will need to be considered if the technology is embraced in the future. Who pays for the kiosks, how providers are compensated, and how that compensation is collected are all variables that will require further deliberation. The survey data collected in these projects seem to indicate that, while a pilot was willing to pay for a remote examination, they may not be willing to pay more than an in-office exam simply based on convenience. Providers also suggested that, even though the rudimentary system used for these proof-of-concept studies was not necessarily better compared to an in-person visit, the majority of providers did indicate that they would be willing to work in the environment of performing remote exams in the future -- but reimbursement for doing this type of work is yet to be determined.

The Future

The literature supporting telemedicine for forensic certification examinations spans several domains—forensic mental health assessments, forensic sexual assault examinations, and medicolegal evaluations—but has not been tested within the domain of aeromedical certification assessment.

For forensic mental health assessments, such as competency to stand trial and psycholegal evaluations, Luxton & Niemi (2020)[2] published the first program evaluation of videoconferencing (VC) for adult forensic competency-to-stand-trial (CST) evaluations in Washington State. Across 50 evaluations conducted at jails, state hospitals, and restoration facilities, psychotic symptoms did not impair interviews, and 13 of 14 evaluators reported satisfaction and planned to continue using VC. Luxton, Lexcen & McIntyre (2019)[3] provided a comprehensive review concluding that VC is a reliable method for conducting CST interviews, including with defendants with psychotic symptoms. Benefits included lower operating costs, reduced travel, improved safety, and easier scheduling. Drogin (2020)[4] examined forensic mental telehealth assessment (FMTA) in the context of COVID-19, concluding that FMTA is now a permanent part of the forensic evaluation landscape, with no successful legal challenges mounted against it. Studies spanning two decades support its use for court-sanctioned psychiatric and psychological evaluations. Skala, Chavez, Anderson & Gulrajani (2023)[5] surveyed forensic evaluators across pre-pandemic, intra-pandemic, and post-pandemic periods. VC use for forensic assessments increased from 36.3% to 60% during the pandemic. Evaluators with prior VC experience reported higher perceived validity of psycholegal determinations compared to those without experience. Courts in many jurisdictions did not revert to in-person proceedings even after the pandemic abated.

Mars et al. (2012), cited in the above review, conducted a literature review of VC usage for forensic mental health assessments across four countries and found no successful legal appeals were mounted based on VC usage.

Virtual/telemedicine exams have been used in the domain of forensic sexual assault examinations, when time is of the essence and availability of experienced providers is limited. Miyamoto et al. (2014)[6] demonstrated that rural hospitals using telemedicine for pediatric sexual abuse forensic examinations had significantly higher quality scores across multiple domains — general exam, genital exam, documentation, overall assessment, photo/video quality, and diagnostic accuracy — compared to hospitals without telemedicine support ($p<0.05$ for each). The SAFE-T (Sexual Assault Forensic Examination Telehealth)[7] System has been implemented across 14 underserved hospitals, providing teleSANE consultation to nearly 400 sexual assault survivors. Ninety percent of patients perceived that telehealth improved their care, and nurses reported significantly increased confidence in performing complete forensic examinations. Shaw et al. (2022)[8] evaluated rapid conversion to teleSANE during COVID-19 in Massachusetts, demonstrating that it is feasible to rapidly convert hospitals from in-person to teleSANE care with appropriate planning and expertise.

Within the domain of medical-legal and independent medical evaluations, several studies demonstrated early successes. Steadman et al. (2022)[9] conducted a systematic search on virtual independent medical examinations (vIME) for medicolegal purposes, concluding that remote examinations have utility for legal matters such as causation of injury assessment, treatment approvals, and fitness evaluations, particularly when supplemented by allied health practitioners and objective clinical adjuncts. Taalab et al. (2025)[10] described the ARMED (Augmented Reality Assisted Medical Evidence Collection and Documentation) telementoring model for forensic examination of violence victims, demonstrating a robust telemedicine solution for real-time guidance during forensic evidence collection.

Even for diagnostic validity in guidelines, there have been a variety of references showing compelling case-use utility. A systematic review by van der Merwe et al. (2024)[11] of 35 studies comparing telehealth with face-to-face psychiatric interviews found good agreement and reliability across a broad range of conditions, supporting telehealth as a viable alternative when in-person evaluations are not feasible. The American Psychiatric Association (2017, 2022) has issued guidelines affirming that synchronous videoconferencing appears comparable to in-person diagnostic reliability, with no studies providing strong evidence that VC is less reliable.[12] These findings should not be generalized to FAA aeromedical mental health evaluations. Certain conditions, particularly those associated with impaired insight, require in-person evaluation, and the cited telehealth literature does not establish suitability or equivalent safety for those evaluations.

Schölin et al. (2021) discussed the ethical evolution of remote Mental Health Act assessments in Scotland, noting that while in-person assessments remain preferable, remote assessments may be acceptable and even preferable in certain circumstances.[4] Shore et al. (2008) similarly documented telepsychiatry civil commitment evaluations for rural American Indian reservations.[13]

These studies involved clinical, civil-commitment, or psycholegal contexts with purposes, populations, decision thresholds, and consequences that differ from FAA aeromedical certification. They are included only to describe broader experience with videoconferencing and do not demonstrate suitability for aeromedical mental health evaluations.

Within the available literature on telemedicine use within the mental health realm, consistently identified concerns include restricted psychological testing administration, limited nonverbal behavioral observation, technology-related issues, rapport-building challenges, and confidentiality risks. Evaluators in the cited mental health literature reported fewer concerns after gaining experience with videoconferencing. The kiosk studies similarly suggested that participating clinicians became more comfortable with the technology through repeated use. This limited similarity concerns user familiarity only and should not be interpreted as evidence that remote FAA aeromedical mental health evaluations are valid, reliable, or appropriate. Neither study evaluated applicants with specific mental health abnormalities, assessed the validity of remote mental health findings, or examined whether an AME could adequately evaluate insight, judgment, behavioral presentation, or other factors relevant to aviation safety. The findings therefore provide no evidence supporting the substitution of remote examinations for FAA-required in-person mental health evaluations. The appropriate modality must remain governed by the condition being evaluated and applicable FAA policy. Importantly, the small, selected study provides preliminary evidence that participating clinicians could identify several prespecified physical abnormalities, but it does not establish equivalence or an equivalent level of safety. The technology may warrant further study as a means of addressing geographic gaps in access for appropriately selected applicants.

In summary, these sequential studies provided preliminary and incomplete evidence regarding the technical feasibility and user acceptability of a kiosk-based model for selected components of an aeromedical examination. The small, selected samples do not establish diagnostic equivalence, an equivalent level of safety, or suitability for operational implementation at this juncture. The studies did not evaluate specific mental health abnormalities or the adequacy of remote FAA aeromedical mental health evaluations.

PROPOSED FUTURE RESEARCH

Based upon data obtained in the proof-of-concept study, followed by the preliminary validation study, the following sequential projects are proposed. Before Phase III, the protocol should incorporate, refine, and validate methods for all required examination components, including visual field screening and visualization of the eye fundus as technologies enable. It should also define the limitations of remote observation and screening for mental health concerns; identify findings and conditions requiring an in-person evaluation; and ensure compliance with applicable FAA requirements. Separate validation would be required before drawing conclusions about any remote aeromedical mental health evaluation. After further refining the current model, progression through phases will be dependent on predefined benchmark criteria. The current results do not support operational implementation or replacement of in-person FAA examinations at this time.

Phase III: Multicenter feasibility trial

Development and placement of a pre-production kiosk model at academic institutions and/or flight schools could provide a higher-volume data set to assess the ability to detect safety-sensitive physical abnormalities while achieving an adequate sample size to perform statistical calculations on overall efficacy.

Phase IV: Operational implementation trial

Given adequate statistical power and if favorable data are realized from Phase III, initiating a beta-testing model within a research paradigm at several locations would allow the FAA to review the logistics and operational implementation of a kiosk-based remote examination model before introducing it as a possible alternative to the in-person office model for flight physicals more broadly.

Phase V: Longitudinal FAA certification outcomes

The agency could then compare aeromedical certification performed in the office setting versus the remote model to determine, longitudinally, the prevalence of exams requiring deferral, AME errors, or other factors unique to the remote testing paradigm.

Phase VI: Cost-effectiveness analysis

Ultimately, a cost-effectiveness analysis could be performed in conjunction with the developer of the kiosk-based model to assess examination fees, as well as analyses looking at office overhead and physician reimbursement for each type of examination environment.

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