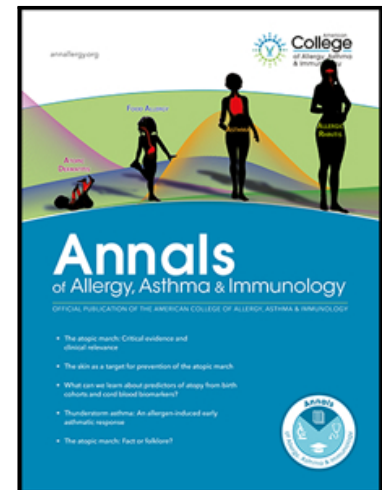


THE IMPACT OF TELEMEDICINE AS A DISRUPTIVE INNOVATION
ON ALLERGY/IMMUNOLOGY PRACTICE

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THE IMPACT OF TELEMEDICINE AS A DISRUPTIVE INNOVATION ON ALLERGY/IMMUNOLOGY PRACTICE

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Abstract

Background: Urban minority preschool children are disproportionately affected by asthma with increased asthma morbidity and mortality. It is important to understand how families manage asthma in preschool children in order to improve asthma control. **Objective:** This study examines family asthma management and asthma outcomes among a low-income urban minority population of Head Start preschool children. **Methods:** The Family Asthma Management System Scale (FAMSS) assesses how families manage a child's asthma. 388 caregivers completed the FAMSS at baseline. Asthma outcomes were assessed at baseline and prospectively at 6 months, including asthma control (based on the Test for Respiratory and Asthma Control in Kids), courses of oral corticosteroids required, and caregiver health-related quality of life (Pediatric Asthma Caregiver's Quality of Life Questionnaire (PACQLQ)). Multiple regression models assessed the relationship between the FAMSS Total Score, FAMSS subscales, and asthma outcomes.

Results: Higher FAMSS Total scores were associated with fewer courses of oral corticosteroids required ($b=-0.23$, $p<0.01$) and higher PACQLQ scores ($b=0.07$, $p<0.05$). At baseline, higher Integration subscale scores ($b=-0.19$, $p<0.05$) were associated with fewer courses of oral corticosteroids required, and higher Family Response scores were associated with higher PACQLQ scores ($b=0.06$, $p<0.05$). However, higher Collaboration scores were associated with lower PACQLQ at baseline ($b=-0.06$, $p<0.05$) and 6 months ($b=-0.07$, $p<0.05$).

Conclusion: Among this population of low-income minority preschool children, understanding how a family manages their child's asthma may help identify gaps for education to possibly improve caregiver asthma-related quality of life and reduce courses of oral corticosteroids.

Key messages

- Telemedicine is a disruptive innovation.
- Encouraging competency with telemedicine and other emerging technologic innovations is increasingly important for allergy and immunology providers.
- A dramatic surge in publications concerning telemedicine and allergy has occurred in recent years; this likely correlates with increasing adoption of telemedicine in our specialty.
- Properly selected patients with conditions within the spectrum of allergic/immunologic disorders can experience optimal care outcomes via telemedicine.
- Based on a number of influences, including recent behavioral and demographic trends, use of telemedicine will continue to be an important component of allergy/immunology care post-pandemic and in the future.

Introduction

In the spring of 2019, the American College of Allergy, Asthma, and Immunology and the American Academy of Allergy, Asthma, and Immunology collaborated to form a Joint Task Force on Telemedicine and Technologic Innovation, chaired by Tania Elliott, MD, and Jay Portnoy, MD. The decision to create such a task force at that time reflected the recognition on the part of the leadership of our specialty societies that promoting awareness and encouraging competency with telemedicine and

other emerging technologic innovations would be increasingly important for the practice of allergy and immunology. The goals of this Joint Task Force are displayed in Table 1. The resources planned for annual meetings are yet to be realized, but are intended for future meetings.

When this Joint Task Force was created, we were unaware of the *foehn* wind in the form of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic that would intrude one year later. The pandemic not only led to dramatic changes in our lives, but also catalyzed a dramatic surge of telemedicine use in the health care marketplace, based on the need to reduce in person visits in the ambulatory setting.

In order to fully understand telemedicine and the prominent role this technology will play in the future, there are several key influences that must be appreciated.

Disruptive Innovation

The first influence is a concept that can be regarded as being at the border between economics and psychology. Disruptive innovation is a term coined in 1997 by Clayton Christiansen, Harvard economist (1), who unfortunately passed away in January 2020. Such an innovation explains a phenomenon in which a simple, convenient, and more affordable solution, in an industry previously dominated by a more expensive and more complicated service, can become the norm.

The disrupter takes root initially at the bottom of a market, proceeds to move “up market”, eventually reaching a position to challenge or even supplant the market leader. The entrant begins by successfully targeting overlooked segments of the marketplace, then becomes successful based on consumer demand trajectories that frequently include market segment customers more motivated by price and ultimately mainstream customers. A key element of the innovation is that it offers a service that does not provide everything the existing market leader offers, but establishes a foothold in the market by offering more suitable functionality. The disrupter typically opens the gates for new populations of consumers to have market access.

Several examples of disruptive innovations are displayed in Table 2. One that can be readily appreciated is the evolution of computers. When desktop computers were introduced in the 1980s, one could do much more with a mainframe computer. However, very few individuals could afford or operate such a computer. The enabler of this innovation was the development of a microprocessor, which simplified computer development so that Steve Jobs and Steve Wozniak could build an Apple computer in a garage, and Michael Dell could put a computer together in his dormitory room (1). As opposed to the business model used for mainframe computers, which entailed high overhead costs with high profit margins and low unit volumes, the model for personal computers entailed low overhead costs, low profit margins, and high unit volumes.

A series of innovations has occurred with computers. Laptop computers were introduced, which compared with desktop computers had yet further suitable functionality. More recently, hand-held devices have moved “up market”. One can appreciate from this description that the disruptive innovation is not intended to make a good product better. Rather, compared with the market leader, the new innovation transforms the product such that it has become more simple and/or affordable. We are motivated to use the more recent innovation based on its more suitable functionality.

The telemedicine encounter sacrifices a number of elements of the traditional provider-patient encounter. We are unable to perform procedures, such as skin testing, spirometry, or skin biopsy. We may find establishing rapport to be more challenging, particularly in the setting of an initial patient encounter. However, just as is the case with using our smartphone in lieu of our laptop computer, there are other aspects of telemedicine that serve to drive an “up market” trajectory.

Changing Perceptions of Time

We have evolved into a species that is increasingly impatient with time (2). This can be regarded as a major influence that has encouraged, and will continue to drive, a reliance on telemedicine.

We are habitually in a rush.

Time is at a premium.

The next time you ride an elevator, carefully examine your experience. You may be surprised to learn that riding an elevator happens to be a very well-studied phenomenon. It is a situation in which our perception of time is altered. Our ideal wait time for an elevator is approximately 15 seconds. After 40 seconds, people waiting for elevators may become visibly agitated (3). When we ride the elevator, each of us has faced the common experience of another individual exiting the elevator at a lower floor. At such times we endure a phenomenon called "door dwell". We may become impatient and push a button that engineers can tell you is the button on an elevator from which paint fades the soonest. It may interest you to learn that many of the buttons that proudly declare "Close Door" aren't even wired (4). As it happens, door dwell only last 2-4 seconds. But sometimes, doesn't it seem like a lot longer?

A number of companies have flourished in our lifetimes that have created new segments of our economy by exploiting our need for haste.

McDonald's is the world's largest restaurant chain by revenue. As of 2015, McDonald's had more 36,000 locations in more than 100 countries, serving over 69 million customers daily. (5). In the United States, drive-through, which may be regarded in many instances as a symptom of haste, accounts for 70 percent of sales (6). The impact of McDonald's on our economy is massive. McDonald's is the single largest purchaser of beef, pork, potatoes, and apples. An estimated one in eight workers in the United States have at some time been employed at McDonald's (7). The impact of McDonald's is global: *The Economist* uses a "Big Mac Index", a

comparison of the cost of a Big Mac in various world currencies, for informally gauging the purchasing power parity of various currencies. Twenty-five years ago, McDonald's offered refunds to customers who weren't served within 55 seconds. Its original mascot, prior to Ronald McDonald, was a character shaped like a hamburger, called "Speedee" (3).

Another *fast-food* success that illustrates our preoccupation with haste is Domino's Pizza. Tom Monaghan grew Domino's from a single pizza location to a chain of several thousand outlets. However, there was a time early in its history that Domino's was on the verge of bankruptcy. Domino's became successful after a guarantee for fast service was made: if a pizza wasn't delivered in 30 minutes, it was free (8).

Millennials have carried on the preoccupation with haste exhibited by the Baby Boomer generation, whom they surpassed as the most numerous generation in 2019; Generation X is projected to outnumber baby boomers in 2028. (9). Indeed, the trend described above has moved forward. For busy millennials, among whom, in addition to speed, convenience is also a priority, meals tend to be consumed on the go (10). Several food products that require time or several steps for preparation have suffered, including cereals and canned tuna. Brands have responded. Sales of ready to eat pouch tuna have surged. Next to water, coffee is the most frequently consumed daily beverage in the United States. While consumption of carbonated soft drinks has declined among millennials, coffee consumption has increased. But who has the time for grinding beans? For millennials who'll be drinking their coffee while moving along, sales of cold coffee, specialty instant coffees, and ready-to-drink

coffee have surged. As a group, millennials are twice as likely to drink cold coffee compared to older consumers (11).

A recently published survey by aetnahealth (12) that analyzed 23.5 million patients across 7,258 practices: primary care, cardiology, obstetrics/gynecology, and mental health, from February – April, 2021, found that patients more than 60 years old were less likely to use telemedicine. Other survey data show that more than 70% of younger generations (millennials, Generation X, and Generation Z) prefer telehealth based on convenience; only a quarter of baby boomers indicated a preference for telehealth compared with in-person care (13).

A Brief History of Telemedicine: The Jetsons, Watson, and Michael Crichton

Elroy isn't feeling well and declares that he's going to have to stay home from school. As shown in Figure 1, rather than making a trip to the doctor, which as one can imagine was standard practice in 1962, Jane Jetson arranges a telemedicine visit. Those of us who recall watching the Jetsons perhaps suspected that someday in the future, technology would advance so that telemedicine encounters would be commonplace.

However, the origins of telemedicine, which in the context of this review will be defined as healthcare delivery via information and communication technology, (14) predate the Jetsons.

Alexander Graham Bell, uttering the first words ever spoken on the telephone in 1876, famously said: "Mr. Watson, come here, I want you." What is not generally known is the reason he called for his colleague. Bell had just upset the wet battery

powering his transmitter, spilling sulfuric acid on his clothing. Thomas Watson responded to the summons to administer first aid, in addition to, we can assume, celebrating what they would surmise was the first telemedicine encounter (15). A clinical encounter that subsequently appeared in the Lancet in 1879 provided anecdotal evidence in support of telemedicine. A woman suspecting her baby had croup contacted the child's grandmother. She telephoned their primary care physician at midnight, who in turn phoned the mother. She was asked by the physician to "lift the child to the receiver and let me hear it cough". Subsequently the physician concluded: "That is not the croup". The physician advised them to stay in bed, and "the trio settled down happily for the night" (16).

A more recent development, which can be regarded as a closer prototype for current telemedicine, occurred in 1968 in Boston. A medical station was established linking Logan Airport with Massachusetts General Hospital. The Logan Medical Station was a tele-diagnostic unit that utilized closed circuit television and enabled providers in the hospital's emergency department to evaluate patients at the airport located approximately three miles away. Michael Crichton, then a 3rd year medical student at Harvard Medical School, described the experience as one in which "the doctor's stethoscope is three miles long" (17).

Telemedicine in Allergy and Immunology

For guidance on how to implement telemedicine at an academic center or in a community practice setting, its integration with electronic medical records,

regulatory issues, and reimbursement, the reader is referred to several recent reviews (18-23).

The increasing frequency of annual publications in our specialty concerning telemedicine, shown in Figure 2, has occurred in parallel with, and can be interpreted as a reflection of, the acceleration in adoption of this technology in recent years among Allergy/Immunology providers.

As noted above, viewing telemedicine as a disruptive innovation is an acknowledgment that this will not provide all of the opportunities that exist for a face-to-face encounter. For this reason, there are certain types of clinical encounters for which, and certain types of patients for whom, telemedicine encounters merit consideration – several examples are:

- A visit dedicated to discussion of diagnostic test results.
- An encounter for which physical examination is not a critical aspect of diagnosis or management.
- A follow-up visit to determine of the success of a therapeutic intervention based on assessment of benefit compared with harm/burden.
- Facilitation of access based on distance or travel barriers.

In contrast, for patients in whom a direct physical exam is necessary, or for whom a procedure (e.g., skin testing, pre/post bronchodilator spirometry, food/drug challenge) needs to be performed, a telemedicine visit would not be appropriate.”

Telemedicine: Evidence and Outcomes

What is the evidence supporting the utility of telemedicine for improving patient care outcomes – particularly for patients with allergic/immunologic disorders?

Asthma

A number of studies have focused on patients with asthma. In a study by Portnoy, et al (24), children with asthma residing in remote locations were offered a choice between follow-up visits in person or via telemedicine. Assessments at 30 days and 6 months found that asthma control test (ACT) scores for children and adolescents (ACT or Childhood-ACT) for telemedicine were non-inferior to in-person visits. A more recent report (25) demonstrated the utility of telemedicine in patients with asthma and chronic obstructive pulmonary disease (COPD) to improve and ensure proper use of inhalers. This intervention was associated with high patient satisfaction and was effective for resolving errors in inhaler use.

Penicillin Allergy

Staicu et al (26) described the utility of telemedicine for “de-labeling” patients with self-reported penicillin allergy. Penicillin-allergic inpatients receiving alternative antibiotics were prospectively identified. Patients underwent skin testing performed by a trained physician assistant, followed by a telemedicine consultation. Of 46/50 skin test negative patients, 33 were switched to penicillins; more than \$30,000 was saved during the study period. These data highlight the utility, and at this time unrealized potential, of telemedicine for improving access to Allergy/Immunology specialty services to address the serious public health

challenge our specialty faces for “de-labeling” the approximately 1 in 10 individuals in the general population who self-report penicillin allergy (27).

Atopic Dermatitis

After in person evaluation, Armstrong et al (28), randomized adults and children with atopic dermatitis to follow up visits in-person every 2 months for one year, or via direct access on-line. Subjects randomized to the latter group transmitted clinical images and histories, and then received management recommendations asynchronously. Equivalent improvement in clinical outcomes was observed in the atopic dermatitis patients managed by direct-access online compared with those who had in person visits. Kornmehl et al (29) performed a similar study, and found that when patients with atopic dermatitis were followed via telemedicine encounters over time, improvements measured in quality of life were similar to atopic dermatitis patients who were followed via in person visits.

The above reports illustrate the potential utility for properly selected patients with these and other conditions within the spectrum of allergic/immunologic disorders to experience optimal outcomes by receiving care via telemedicine.

Critical Appraisal of Evidence

Queiroz-Flumignan (30), performed a Cochrane systematic review to summarize evidence supporting the utility of telemedicine. Ten systematic reviews containing data on 53 randomized controlled trials (RCTs), with 6,836 participants, were

analyzed. These systematic reviews were focused on management of patients with asthma (2), COPD (1), congestive heart failure (1), multiple sclerosis (1), stroke (1), parents of high risk newborns (1), HIV (1), low vision (1), and children and adolescents with chronic pain (1).

The two systematic reviews on asthma (31,32) included 24 RCTs with 4368 subjects. Evidence was downgraded in these two reviews based on a number of methodological shortcomings, including imprecision, inconsistency, lack of blinding, risk of bias, publication bias, and data on selected outcomes being judged as low quality based on wide confidence limits and small numbers of events (30). This review concluded the quality of evidence for telemedicine was too low to support or refute its use in clinical practice. More specifically, the current evidence is insufficient to judge whether telemedicine is effective, and if so, for which patients in which setting. Particularly in view of the burgeoning of telemedicine encounters that occurred in 2020 and 2021, since publication of this systematic review, there is a need for adequately powered, methodologically sound studies to permit a critical appraisal of its effectiveness.

Telemedicine: Future potential

Telemedicine holds the potential for transforming medicine by improving access to medical care and providing a more affordable way of delivering care.

There are several looming areas that will likely serve to fuel further demand for telemedicine services.

Improving Access

Approximately 59 million Americans reside in areas with a shortage of health care providers (33). Residents of rural areas are more likely compared with urban residents to die prematurely from all of the five leading causes of death in the United States: heart disease, cancer, unintentional injury, chronic respiratory disease, and stroke (34), and are more likely to have impaired access and challenges in continuity of care. Travel over long distances is also a barrier, particularly when patients are ill. Telemedicine can address these challenges by serving as an avenue for communication, and for monitoring patients with chronic disease, including asthma (14,35). Telehealth can also provide care promptly in emergencies, for instance by providing “telestroke” services that connect rural hospitals with specialty centers (36). Similarly, management of anaphylaxis may also be facilitated via telemedicine (37).

Chronic medical conditions

An estimated 50% of adults in the United States have a chronic medical condition. Chronic disease accounts for 75% of all health care expenditures and 70% of all deaths (33). Economic productivity lost due to chronic disease amounts to \$4 trillion per year – approximately 1/5 of the entire United States economy (38). These costs are projected to increase as our population ages. Management via telemedicine has been studied in patients with congestive heart failure, COPD, diabetes and other conditions (14). For patients who have conditions cared for by allergy/immunology providers -- not only asthma and atopic dermatitis (see above), but also common variable immune deficiency, chronic urticaria, and C1 inhibitor

deficiency syndromes -- there are opportunities for management via telemedicine that have not yet been realized.

Telemedicine 2020: The breakthrough year

As is the case at many academic centers, we have a number of performance measures for our Department at Cleveland Clinic. These include volumes of outpatient encounters, wait times for new patient appointments, and patient satisfaction scores. In recent years, a “target” number of telemedicine visits per quarter was included among these metrics.

As illustrated in Figure 3, although our numbers of telemedicine visits per month surpassed this target pre-pandemic, it is of interest to note in retrospect that telemedicine visits only comprised 1% of our total visits! With the arrival of the SARS-CoV-2 pandemic in March 2020, in accordance with recommendations for care of patients with allergic/immunologic disorders (38), our outpatient practice pivoted to expand telemedicine visits. These visits escalated dramatically, such that in May 2020, telemedicine visits reached a zenith of 84% of our outpatient encounters. Since then, the volume of in person encounters increased in association with evolution of the pandemic and corresponding shifts in the healthcare marketplace (40).

If Figure 3 were to be expanded to also illustrate the monthly rates of telemedicine visits at other academic centers in the United States, one would expect to observe a similar pattern. The more interesting exercise is to compare the columns at the far left with the far right of Figure 3. In contrast to pre-pandemic, telemedicine visits

now comprise a more substantial proportion of clinical encounters. The steady state that will be observed in 2022 and subsequent years is unknown; however this review provides evidence supporting the contention that, based on evolving behavioral and demographic trends in the population, we are unlikely to return to the *status quo ante*.

What If?

In 1931, an intriguing collection of “what if” chapters in “counterfactual” history, edited by JC Squires, was published (41). Each entailed an alternative history, speculating on what might have transpired had an event not happened or had it happened in a different fashion. A number of luminaries contributed. The chapters included one authored by Winston Churchill, speculating on the outcomes that would have followed had the Confederacy won at Gettysburg. Others included Napoleon winning at Waterloo, and the gun used by John Wilkes Booth at Ford’s theater failing to fire such that Abraham Lincoln lived on.

Counterfactuals can serve an important role in providing perspective. Were we to author a “what if” chapter on what would have happened had the pandemic not occurred in March 2020, it is obvious that Figure 3 would look much different. However, this review makes the case, based on how we have evolved as a species in recent decades, that the aggrandizement of telemedicine as an important component of the health care marketplace would have happened in a different way, but still would have occurred. The SARS-CoV-2 pandemic provided the “tipping point” (42).

The pandemic ushered in a time during which telemedicine has been used to enhance “connectedness”. Access has been improved. We have learned that patients with certain conditions, at a certain phase of their illness, or in distant geographic locations can receive care via this technology. This implementation reflects an extension of our current business model. However, if telemedicine serves only this role, aiding health care providers in performing the job we’ve always done, it will not have fulfilled its full potential as a *disruptive innovation* (1). The next phase of telemedicine will likely entail actual disruption: (a) direct generalist consultations with specialists; (b) team approaches via zoom technology for management of complex cases; (c) use of digital devices to monitor outcomes; (d) enhancements of behavioral models to manage chronic medical conditions; (e) integration with artificial intelligence and robotic technologies (14,35,36,43).

Conclusion

Telemedicine, in addition to serving other needs, allows patients to receive care without leaving home, while spending less time in a waiting room, on demand, and in less time. As is the case with many aspects of our lives: how we shop, how we interact, how we maintain relationships, the world has changed.

The healthcare marketplace is also changing. Telemedicine has the disruptive potential to continue to move forward as a purpose-built business model, to encourage a successful transition to population health management via facilitating

stronger relationships with communities and leveraging more optimal self-management of chronic conditions (44).

The intertwining of the physical with the digital environment will continue to move forward and evolve.

The future of allergy/immunology care will entail traditional medicine along with telemedicine.

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Legends



Figure 1: This simulation of a telemedicine encounter is a scene from *The Jetsons* – an American animated sitcom shown in 1962 on the American Broadcasting Company, depicting the future. At the time, this was viewed as a depiction of the distant future; however, as we have recently appreciated, the future is now!

Reproduced with permission: <https://www.smithsonianmag.com/history/the-episode-where-george-jetson-rages-against-the-machine-146315456/>

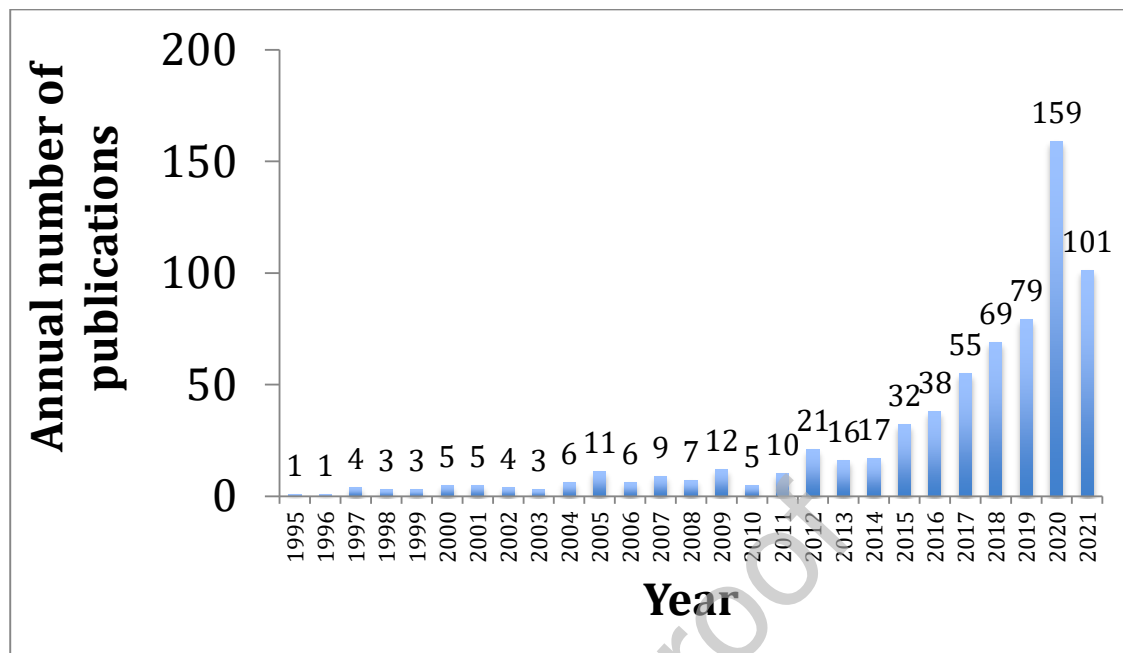


Figure 2: Publications per year pertaining to telemedicine in our specialty. These data were tabulated by the author, by entering the terms “telemedicine” and “allergy” in a PubMed search on August 29, 2021.

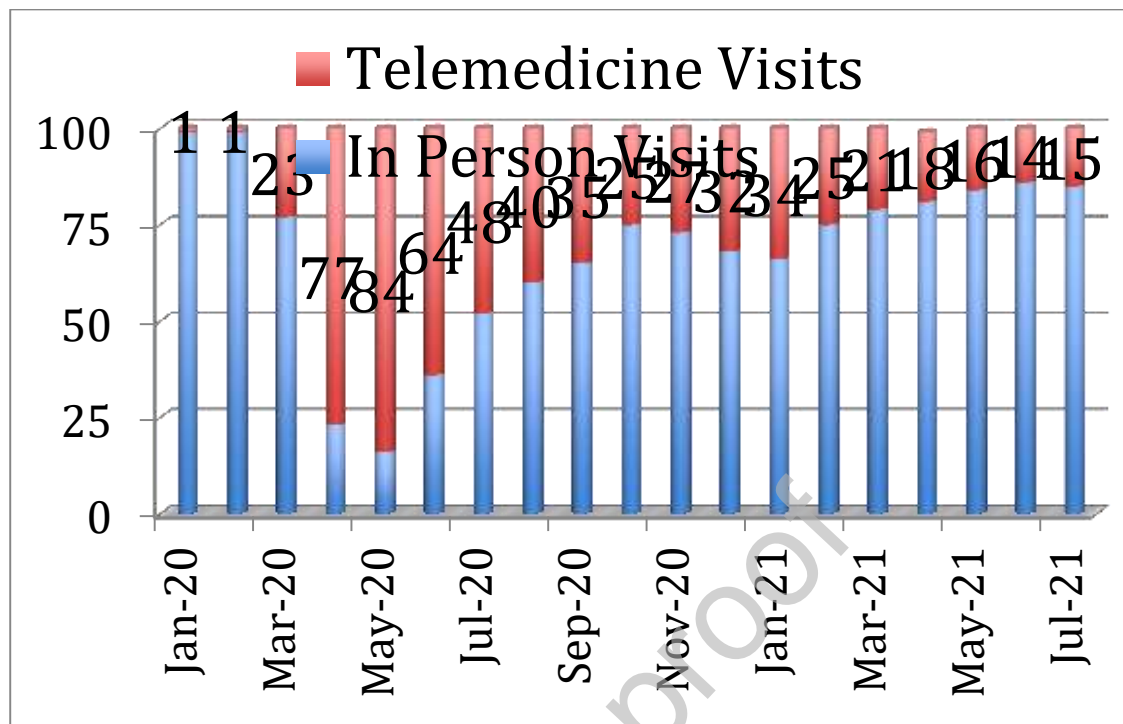


Figure 3: Monthly percentages of telemedicine encounters in the Department of Allergy and Clinical Immunology at Cleveland Clinic, Cleveland, OH: January 2020 – July 2021.

Table 1**Goals of the AAAAI/ACAAI Joint Task Force on Telemedicine and Technologic Innovation**

- Raise awareness among the membership of opportunities currently available to utilize telemedicine and other technology.
- Facilitate access to these opportunities for our members.
- Develop educational resources on telemedicine and technology for a variety of platforms, including online, print, sessions at AAAAI and ACAAI annual meetings, and tools that can be utilized by local and regional allergy societies at their meetings.
- Collaborate with companies who make technological devices to provide hands on educational opportunities in the exhibit halls at annual meetings or via learning/training sessions outside the exhibit area.
- Develop a “how to” guide for members that details best practices for reviewing and negotiating agreements/contracts with telemedicine and technology companies.
- Prepare a “Consumer Reports” style review of various telemedicine and technology companies.

Table 2
Disruptive Innovations

Dominant Market Service	Disruptive Innovation
Main Frame Computer	Desktop Computer
Personal Computer	iPhone
Department Store	Amazon
World Book and Encyclopedia Britannica	Online Encyclopedia
Cabinet/Tabletop Radio	Transistor Radio
Canon, Kodak, Minolta, Sony Cameras	Cell Phone Photography
Blockbuster	Netflix