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DIGITAL CARE PATHWAY FOR AMBLYOPIC PATIENTS IN NORTHERN OSTROBOTHNIA HOSPITAL DISTRICT

a Development Project

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ABSTRACT

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Introduction: Amblyopia is one of the leading causes of children's visual impairment. When detected early, the negative impacts of amblyopia can be hindered but to succeed, it requires commitment from the patient and their guardians, regular care, controls, and resources. Monitoring children's visual acuity is important as it is an indicator of the development of amblyopia. Finland has large healthcare districts, and patients may need to travel long distances to get the treatment and go to regular controls, which is not cost-effective. Currently, the health and social services reform sets a great opportunity to proceed with the mission how to find new possibilities for improving the care path for amblyopic patients. The Northern Ostrobothnia Hospital District was in a need of a digital care pathway to complement traditional healthcare in treating and monitoring amblyopia.

Purpose: The purpose of this development project was to gather all the relevant information about amblyopia for the patient and their guardians in one place and to create an accessible contact channel for the patients. At the same time, efforts were made to find reliable methods for controlling visual acuity remotely.

Methods: This development project was research-based and was pursued with a descriptive literature review. Furthermore, the project was pursued through The Health Village model of development and included the design and script of the digital care pathway.

Results: As a result, a basis of the digital care pathway for amblyopia was made for The Northern Ostrobothnia Hospital District using the platform of The Health Village to the point where the implementation phase can start. The digital care pathway includes five stages: 1) logging in, 2) information about amblyopia, 3) treatment plan, 4) contact channel, and 5) control measurements.

Conclusions: The Health Village offers a good portal for directing the patient to a reliable source of up-to-date information. Based on this development project, the remote visual acuity control of the amblyopic patients could be made by local optometrists in the private sector or public health nurses in child health clinics or centres performing the intermediate visual acuity control. In order to get a functional digital care pathway, the pathway should be tested with a control group of possible future users. Therefore, within the limits set by its resources, the Oulu University Hospital continues to reach the implementation phase of the digital care pathway.

Keywords: amblyopia, amblyopia control, digital health care services, digital care pathway

CONTENTS

1 INTRODUCTION

Amblyopia is one of the leading conditions causing visual impairment in children (Evans, 2022a, p. 175). Approximately 2-5% of children are affected by it (Tailor et al., 2016). The symptoms are very clear and visible if the binocularity is disturbed somehow for a person with normally developed binocularity. Instead, with children without fully developed binocularity the symptoms of disturbed binocularity can stay hidden (Erkkilä & Lindberg, 2011). Therefore, amblyopia can be hard to detect in daily life and needs to be controlled closely by health care. Monitoring children's visual acuity is important as it is an indicator of the development of vision (Kvarnström et al., 2001).

When detected early, the negative impacts of amblyopia can be hindered but to succeed, it requires not only commitment from the patient and their guardians but also regular care, controls, and resources. However, in Finland, the health care resources, especially in eye health, are already struggling to answer to the needs and will be even more in the future due to the aging population. Furthermore, the covid-19 pandemic has caused an extra burden on health care. One solution for increasing the health care resources is telemedicine (Keveri, 2022; Merioksa, 2020; Steren et al., 2021), which could also be used to assess ophthalmology patients. Finland is a country with long distances and large health care districts, and patients may need to travel hundreds of kilometres to get the treatment and go to regular controls, which might not be cost-effective. Nowadays the Northern Ostrobothnia Hospital District covers 30 municipalities, and the longest distance to the specialized medical care unit can be almost 300 kilometres. Currently, the health and social services reform will restructure the organization of public healthcare and social welfare giving reasons to focus on new forms of healthcare services in a people-oriented manner. The health and social services reform sets a great opportunity to proceed with the mission how to find new possibilities for improving the care path for amblyopic patients.

There are good examples of telemedicine, for example, visual screening applications used for the pediatric population (Bastawrous et al., 2015; de Venecia et al., 2018; Silverstein et al., 2021; Yamada et al., 2015). Summers et al. (2022) gathered satisfaction and attitudes towards telehealth during the early phase of Covid-19 from patients, providers and staff in an academic pediatric ophthalmology practice. Both staff and providers had positive attitudes, although attitudes of staff were less positive. Summers et al. (2022) considered it arose from an increased workload, including solving difficulties in the technological part of connections, assembling and mailing home vision testing kits and completing home vision testing. From the patients, the survey showed higher satisfaction with telehealth compared to clinic visits (Summers et al., 2022). Thus, telemedicine to succeed and decrease the workload of the health care workers, attention should be paid to the good technological functionality of the services.

In Finland in Oulu University Hospital, digital care pathways are already running successfully in general health and eye health care. For example, Autio and Kinnunen (2016) developed a service chain for a digital platform in glaucoma care. These examples give promise that also amblyopic patients could be controlled by checking the visual acuity between reception visits via telemedicine. This could save time, resources, and costs and, when well-planned and implemented, be a patient-friendly option for the more traditionally known contact reception. Accordingly, this development project aims to create a digital care pathway for amblyopic patients and their guardians for a Finnish public online service called The Health Village. Furthermore, the aim is also to find reliable methods to remotely perform visual acuity controls for amblyopic patients.

2 THEORETICAL BACKGROUND

Normal binocular vision, also called binocular single vision in different references, is formed from images of the two separate eyes into a single binocular percept. According to Evans (2022a), good and asymptomatic binocular vision compounds from three broad groups; the anatomy of the visual apparatus, the motor system coordinating eye movements, and the sensory system from the eye to the brain integrating the two monocular signals. Stereopsis, which improves motor skills at near distances, is an important result of binocular vision. Also, visual acuity and contrast sensitivity benefit from the binocular view. Therefore, anomalies in any of those three groups can negatively affect binocularity (Evans, 2022b).

One cause of the disturbances in binocular vision is amblyopia, commonly known as the ”lazy eye”, which is the leading cause of visual impairment in children (Evans, 2022a). That is, approximately 2–5% of children are affected by it (Tailor et al., 2016), making it clinically very important especially in children’s eye health care. Next, in section 2.1. amblyopia will be defined, and its symptoms described in detail. Then, section 2.2. focuses on the aetiology of the visual impairment because a broader understanding of the causes of amblyopia is needed to form an information package for the digital care pathway. In section 2.3. examination and diagnosis of functional amblyopia are prescribed, and the following section 2.4. focuses on treatment options and follow-up. Section 2.5. opens up the current state in Finland regarding the screening and controlling of amblyopia. Finally, in section 2.6. digital services in eye healthcare are described.

2.1 Amblyopia

According to Evans (2022a, p. 173), amblyopia is ”a visual loss resulting from an impediment or disturbance to the normal development of vision”. This means that even with optimum optical correction and without any observable ocular pathology visual function is reduced (Barrett et al., 2004). Amblyopia is usually a unilateral condition but sometimes occurs in both eyes (Levi, 2020). Three main risk factors for amblyopia are continuous unilateral strabismus, an unequal refractive error called anisometropia, and an obstruction of the visual axis (Bowling, 2016; Levi, 2020). According to Levi, Knill and Bavelier (2015), the most common disability associated with amblyopia is impaired stereoscopic vision, which may significantly affect visuomotor tasks and locomotion, causing difficulties from childhood to adulthood, for example, by limiting career options. Other deficits include visual acuity loss, contrast sensitivity in high spatial frequencies, and position acuity (Levi et al., 2015). In addition, reduced speed in reading has been reported in binocular viewing conditions from persons having unilateral microstabismic amblyopia (Stifter et al., 2005).

2.2 Aetiology

Evans (2022a) classifies amblyopia as organic or functional amblyopia. Organic amblyopia can be a pathological or anatomical abnormality of the retina from retinal eye diseases, nutritional deficiencies, or toxins, or it can be idiopathic (i.e., the reason is unknown), or congenital. This thesis focuses on functional amblyopia because it is a more common and targeted patient group to the digital care pathway. Thus, it will not deepen more on pathological or anatomical reasons. Evans (2022a) further subdivides functional amblyopia as strabismic, anisometropic, stimulus deprivation, refractive (bilateral ametropic and meridional), and psychogenic amblyopia. (Evans, 2022a).

According to Evans (2022a), the two most common types of functional amblyopia are strabismic and anisometropic amblyopia. *Strabismic amblyopia* results from neural changes in strabismus, causing monocular suppression of the deviating eye (Evans, 2022a). Barrett et al. (2004) contemplated the principles of the neural basis of strabismic amblyopia in their review. Neural changes in strabismus are thought to be due to the misalignment of the visual axes; the fovea of the fixating eye does not pair with the deviated eye's image at the cortex. Furthermore, as strabismic amblyopes does not suffer from diplopia or confusion, it is generally thought to result from neural suppression (inhibition) of the deviated eye's image. (Barrett et al., 2004). *Anisometropic amblyopia*, in turn, results from a refractive error between the eyes, causing a blurred image in the uncorrected more ametropic eye (Bowling, 2016; Evans, 2022a), leading to visual cortex suppression of the eye with the unclear image (McConaghy & McGuirk, 2019). These two forms of amblyopia, strabismic and anisometropic, can coexist. (Bowling, 2016, Evans, 2022a). In *stimulus deprivation amblyopia*, obstruction of a clear image on the visual axis reaching to retina leads to suppression of the visual cortex (McConaghy & McGuirk, 2019). Those obstructions are, e.g., congenital cataracts, ptosis (i.e., eyelid covers the pupil), or corneal opacity. (Bowling, 2016; Levi, 2020). A high refractive error in both eyes can cause *bilateral amblyopia* as the lack of accommodation causing blurred images disrupts the function of the visual cortex (McConaghy &

McGuirk, 2019). In *meridional amblyopia*, high uncorrected astigmatism results in reduced vision in the less focused meridian (Levi, 2020).

In summary, long-term blurred vision leads to amblyopia because the visual cortex ignores the chronically blurred visual input (McConaghy and McGuirk, 2019). Furthermore, the fact that depth perception is most commonly impaired in amblyopia can be inferred to be due to the absence of the two-eye image formation required for binocular vision when the brain obstructs the interpretation of the image of the weaker eye (Levi et al., 2015). Moreover, according to Levi, Knill and Bavelier (2015) the relationship between the stereoacuity and visual acuity is complex. They state that there is more correlation in the visual acuity and stereoacuity within anisometropic amblyopes than in strabismic or mixed (strabismic and anisometropic) amblyopes, as the latter ones are essentially stereoblind even with good visual acuity. However, they state that, overall, poorer visual acuity seems to correlate with poorer stereo acuity (Levi et al., 2015).

At a higher risk for developing amblyopia are the children with ptosis, birth weight less than 1500g, gestational age less than 30 weeks, cerebral palsy, syndromes with ocular involvement, e.g., Down syndrome (McConaghy and McGuirk, 2019). Levi (2020) Amblyopia does not pass on genes, but the amblyogenic factors might (Levi, 2020). For instance, strabismus (Wilmer & Backus, 2009) and refractive errors (hyperopia/myopia; astigmatism) (Hammond et al., 2001) are suggested to have genetic factors. Therefore, a family history of amblyopia or strabismus, might elevate the risk for amblyopia (McConaghy & McGuirk, 2019). Amblyopia develops in the sensitive period of childhood, and the visual acuity can usually develop up to 8 years in strabismic amblyopia and up to teenage years for anisometropic amblyopia with good binocular function (Bowling, 2016), whereas for the binocular vision and stereopsis the critical period peaks at a few months of age (Daw, 2014). The severity of the amblyopia reflects the age it occurred; the earlier the impairment, the more complex the amblyopia is (Levi, 2020). Hence, for better results in treatment, it is essential to detect amblyopia as early as possible (Kirk et al., 2008). For example, a wandering eye, head tilting, squinting of one eye, nystagmus, or strabismus are clinical signs that may direct to amblyopia (McConaghy and McGuirk, 2019). The American Academy of Pediatrics states that visual system screening should begin with newborns and continue at regular intervals throughout life (Donahue & Baker, 2016).

2.3 Examination and Diagnosis

When amblyopia is suspected, a full eye examination should be performed (Evans, 2022a). The test should comprehend the assessment of the position of eyelids, cataracts, corneal opacities, pupillary examination, and ocular motility and alignment, along with vision testing (McConaghy & McGuirk, 2019). Unaided visual acuity should be measured, but the visual acuity with the best corrected refraction is needed for the evaluation of amblyopia. Different circumstances (illumination, contrast, type of test used) will affect the test results, so using standardised measurements is important. Considering this, the age and cognitive abilities of the patient are essential to consider when choosing what test to be used to keep the testability rate as good as possible. In other words, it is not possible to undergo the same test with every patient. Therefore, recording the method and distance used with the test results is substantial. (Evans, 2022a).

When examining amblyopia, at first, it is important to check the pupillary reflexes to detect any ocular pathology since the presence of an amblyogenic factor does not exclude pathology. Moreover, this examination is performed with a bright light to find an afferent pupillary defect and other neurological problems that might affect pupil size and reaction time. (Evans, 2022a). When visual acuity is checked and the best corrected visual acuity differs two lines or more between the eyes, it refers to amblyopia (Bowling, 2016). Binocular function is examined to find out if there are any factors interfering the visual information from one of the eyes to the visual cortex. All the following tests are also recorded for the evaluation of how the amblyopia is responding to treatment. (Evans, 2022a).

The following chapters will present a few examinations to test amblyopia suspicion, as advised above. Furthermore, as this thesis comprehends a digital care pathway for amblyopic patients in the Northern Ostrobothnia hospital district, the tests presented below were selected due to their active use in the Oulu University Hospital.

2.3.1 Testing Preverbal Children

Evaluating vision from preverbal children is challenging due to undeveloped communication skills. According to Bowling (2016), when testing preverbal children, their visual behaviour needs to be assessed along with visual acuity using *looking tests*. The visual behaviour can be tested with attention-grabbing targets informing if the child is visually alert and can fixate and follow the target simultaneously or if there is a unilateral difference. Fixation behaviour can also be tested, preferably with a light, especially when squinting of the eyelid is present. Fixation is observed by covering one eye at a time, and the patient's ability to maintain the fixation is observed. Corneal reflection is also monitored, and fixation can be grated as central or non-central and steady or unsteady. Occlusion can reveal a deficient acuity in the other eye if the child resists the occlusion. Although, it needs to be considered that each eye can have good visual attention but uneven visual acuity, which is a risk factor for amblyopia (Bowling, 2016).

Methods to evaluate the visual acuity of infants are to be few. As noted by Bowling (2016), infants prefer looking at patterns. Therefore, *preferential looking tests*, i.e., Teller and Keeler acuity cards, can be one test to use for visual acuity measurement (Bowling, 2016). Spierer et al. (1999) concluded in their study that Teller acuity cards are suitable for visual acuity screening in infants and preverbal children, despite the high rate of false-positive results. In Teller and Keeler tests, an infant's fixation on the exposed stimulus is observed by the eye movements one eye at a time. Teller and Keeler acuity cards consist of black stripes of different widths. Test results a resolution visual acuity by the highest frequency the infant has reacted (Bowling, 2016). Such measurement is a subjective method and requires experienced examiners. Also, the testing settings are challenging to control, and the results may be misestimated (Vrabič et al., 2021). Therefore, as stated also by Bowling (2016), these test results must always be evaluated with the risk factors for amblyopia as they are not adequate for diagnosis alone.

As stated by McConaghy and McGuirk (2019), *photoscreening* is one option to detect amblyopia in preverbal or uncooperative patients for chart-based vision testing. It evaluates for signs of ocular opacities or misalignment and uncorrected refractive error from the red reflex of both eyes. Nowadays, there are apps for mobile devices, making them more affordable and easier to access compared to a separate photoscreener (McConaghy and McGuirk, 2019). Also, according to Kirk et al. (2008), better treatment outcomes for amblyopia can be achieved with early photoscreening when compared to later photoscreening.

2.3.2 Testing Verbal Children

The gold standard for amblyopia detection is to measure the *visual acuity* using crowded or linear letter optotypes and avoid using less sensitive single letter optotypes (Repka, 2013). The crowding phenomenon is a characteristic of amblyopia (Levi, 2020), and crowding limits the recognition of objects with strabismic amblyopia (Levi et al., 2015). That is, an amblyopic person struggles more with letters in clutter than isolated ones, causing a deficit in central vision. According to Hussain et al. (2012), the crowding phenomenon is common in normal peripheral vision but not in central vision. Moreover, this way, the crowding phenomenon can reveal amblyopia suspicions. Also, according to Birch et al. (2022), visual acuity tests that use isolated optotypes without crowding bars are likely to overestimate visual acuity with amblyopic patients. A crowded test is needed not only for clinical evaluation and accurate diagnosis but also for controlling amblyopia treatment's progression, and this is possible only in verbal children (Bowling, 2016). An eye chart is recommended to be used from the age of three years by The American Academy of Ophthalmology (Bell et al., 2013). Preliterate children are recommended to undergo tests such as crowded Kay pictures, Lea symbols, or Allen Pre-School Vision Test. Letter charts, such as Snellen or Keeler logMAR, can be used with literate children (Bell et al., 2013; Bowling, 2016). According to Bowling (2016), vision testing for children should be performed at 3-4 meters rather than 6 meters because at this distance it is easier to comply with minimal clinical inconvenience. Eyes should be tested separately by occluding the other eye (Bell et al., 2013). An adhesive patch is preferred as a peek-free option (McConaghy & McGuirk, 2019). Optotypes are recommended to be randomized, but if that is not possible, it is suggested to measure the amblyopic eye first (Evans, 2022a).

The Amblyopia Treatment Studies (ATS) from The Pediatric Eye Disease Investigator Group (PEDIG) evaluated visual acuity testing in different age groups. They suggested HOTV optotypes to be used with children aged three to six years (Holmes et al., 2001) and the Early Treatment Diabetic Retinopathy Study (ETDRS) letters for children aged seven years or older (Cotter et al., 2003) due to high level of testability and test-retest reliability. Hered et al. (1997) compared the HOTV and Lea Symbols chart for three- to five-year-old children, and Kvarnström et al. (2001) tested three- to four-year-old children. Both studies found that each test gave similar results, but in the study of Hered et al. (1997), the results suggest that among the three-year-olds, testability was better with the Lea Symbols chart. Birch et al. (2009) compared the Amblyopia Treatment Study HOTV (ATS HOTV) visual acuity protocol and the Electronic-Early Treatment of Diabetic Retinopathy Study (E-ETDRS) protocol from 142 amblyopic patients from age 5.6 to 11.9 years.

They found that the ATS HOTV protocol resulted in slightly better visual acuity in patients with poorer visual acuity than 0.3 logMAR on E-ETDRS. According to their results, the difference was 0.7 lines, equal to 3.4 letters. As a conclusion to their study, Birch et al. (2009) suggested keeping caution when interpreting “near normal visual acuity” when using the ATS-HOTV protocol.

To summarize it is advised to measure the *visual acuity* separately by occluding the other eye. The age affects to the test used and when testing preverbal children, their visual behaviour needs to be assessed along with visual acuity using *looking tests*. With verbal children, it is advised to crowded or linear letter optotypes and avoid using less sensitive single letter optotypes. An eye chart is recommended to be used from the age of three years and to use pictures or symbols with verbal preliterate children and letter charts with literate children. The amblyopic eye is advised to be tested first if randomized optotypes are not available.

2.3.3 Stereoacuity Tests

As stereopsis is most often affected in amblyopia (Levi, Knill and Bavelier, 2015), its measurement is needed for the evaluation. According to (Bowling, 2016) *stereoacuity* is measured in seconds. Normal stereoacuity is 60 seconds; the lower the value, the better the stereoacuity. The stereoacuity test include random dot stereopsis test and contour-based test. For example, the TNO random dot test is viewed with red-green spectacles, and it measures stereoacuity from 480 to 15 seconds of arc at a distance of 40 cm. Another random dot test, the Lang stereotest, the displacement of the dots is seen in turns by the right and left eye, and it does not need any special spectacles due to a built-in cylindrical lens element. It measures stereoacuity from 1200 to 200 seconds. The Titmus test is an example of contour-based tests, which are suitable also for the young children. The Titmus test has a three-dimensional polarized vectograph viewed with polarized spectacles. It has the fly test measuring stereopsis of 3000 seconds that is suitable for young children, the animals measuring stereopsis of 400-100, and the circles measuring 800-40 seconds.

According to Evans (2022a), there are studies suggesting that tests with random dot stereopsis, such as TNO, may reveal strabismic amblyopia, and contour-based tests like Titmus circles are probably less sensitive in the diagnosis of strabismic amblyopia. However, Bowling (2016) suggests that contour-based tests may provide more reliable information if binocular single vision is weak and/or based on abnormal retinal correspondence, as it often is the case with strabismic amblyopes. According to Levi, Knill and Bavelier (2015), Random-dot stereograms is kept as a gold standard measurement for some, as it does not contain monocular information. That is, all the tests have some weaknesses, which may cause confusion in what test should be used, as noted by Levi, Knill and Bavelier (2015). Therefore, it is necessary to be cautious when drawing conclusions from the stereoacuity test in terms of amblyopia, especially if the test subject does not pass the test. In that case, perhaps, based on a single test, it is not possible to judge stereo vision to be completely lacking nor to be fully sufficient if one passes the test.

2.3.4 Binocular Vision Tests

When testing the binocular vision, the age of the patient impacts to variety of the tests. With infants, binocular convergence can be tested to evaluate the *binocular fusion*. The test can be performed from 3 to 4 months old child with an exciting object brought towards the nose and with normal convergence; both eyes should follow the target symmetrically and if not, it can indicate that the fusion brakes due to strabismus, which is one of the main risk factors of amblyopia according to (Levi, 2020). Moreover, over-convergence may denote an incipient esotropia, and divergence may be a tendency to a divergent deviation or lack of interest. (Bowling, 2016).

According to Bowling (2016), with older children, also the degree of binocular vision can be tested for example with the Worth four-dot test for distance and near fixation if there is no manifest squint. It can differentiate between binocular single vision, abnormal retinal correspondence, and suppression of how many dots the patient can detect. Red-green spectacles are needed to perform the test. If the person tested sees less than four dots, it refers to suppression and amblyopia. Whereas a manifest squint is present, a device called synoptophore can be used to detect the binocular function. Simultaneous horizontal, vertical, and torsional misalignment can be measured with it. (Bowling, 2016).

The measure of deviation can be assessed for example with the cover-uncover test, revealing heterotropia and heterophoria. The tests should be performed near and distance; during the test, the patient is advised to fixate on an accommodative target. With manifest strabismus or poor fixation of the deviating eye, a rough objective evaluation of the deviation angle can be done with The Hirschberg test. The test is assessed with a pen torch which the patient fixates. (Bowling, 2016). Motility tests involve eye movement testing in all eight eccentric directions of gaze assessing versions and ductions. Ductions are advised to be assessed if ocular motility is reduced. A pen torch is helpful as it reveals the corneal reflection position for the examiner. (Bowling, 2016).

2.4 Treatment and Follow-up

Treatment of amblyopia is based on treating the cause of vision loss, for example, by removing cataracts, strabismus surgery, and correcting the refractive error with glasses. After that, if needed, the visual input of the better eye is hindered by different options like patching, pharmacologic therapy, and optical penalization to stimulate the amblyopic eye for usage. (McConaghy & McGuirk, 2019). According to Birch (2013), this is due to the assumption that the impaired visual acuity in one eye is caused by preferential fixation of the fellow eye. More accurately, by hindering the non-amblyopic eye, the visual input of the amblyopic eye contributes to the development or recovery of vision (Birch, 2013). According to Evans (2022a), when treating amblyopia, the control interval should be at a minimum of three months and more frequent at the beginning of the treatment. There are a few weeks differences in the recommendations depending on the information source, and alternatives are presented below within the treatment options. The treatment period varies depending on the individual but in the article “Amblyopia and binocular vision” from Birch (2013), it is summarized that amblyopia treatment can be effective beyond the age of 7 years with the possibility that it may require longer patching time. Birch also states that the response rate to treatment may be slower. In their meta-analysis, Holmes et al. (2011) conclude that amblyopia is more responsive to treatment among children younger than 7 years and that some children aged 7-13 years have a response to treatment even though the average response is lower in that age group. According to Birch (2013), the effectiveness of different treatments varies depending on how early treatment is started, the type and severity of amblyopia and how the treatment is complied with.

2.4.1 Primary Treatment

According to Evans (2022a), primary treatment options are refractive corrections and occlusion, keeping in mind that if one approach does not work, another should be tried. McConaghy and McGuirk (2019) emphasize that the first correction should always be refractive error correction following other treatments. Chen and Cotter (2016) state in their article, based on The Amblyopia

Treatment Studies, that starting treatment alone with refractive correction is reasonable for young children with strabismic or anisometropic amblyopia or mixed form of those two. For some, refractive correction can be the only treatment needed. Options for correction are spectacles and more rarely used contact lenses (Chen and Cotter, 2016).

Close follow-up visits should be performed at 6 to 8 weeks intervals. This way, the children that need additional treatments later have better visual acuity, causing less treatment burden and may result in better compliance (Chen and Cotter, 2016). Also, according to Evans (2022a), close follow-up appointments are needed for thorough monitoring for improvement or if the patient requires alternative treatment. He suggests that younger patients are more frequently followed up, and a typical interval should be 4-6 weeks (Evans, 2022a).

2.4.2 Secondary Treatment

According to McConaghy and McGuirk (2019), when *occluding the non-amblyopic eye*, the patch should be applied on the non-amblyopic eye instead of on spectacles. This prevents the child from peaking or looking around the patch. The occlusion period depends on the severity of the amblyopia, but it mainly varies between 2-6 hours per day (Birch, 2013; McConaghy and McGuirk, 2019). Also, the patient's age is considered when planning the time for occlusion per day (Bowling, 2016; Levi, 2020; Evans, 2022a). Activities that can be done during the occlusion are such as crafts, writing, computer or video games, reading, watching tv, or outdoor playing, listed by Chen and Cotter (2016). Levi (2020) states that patching shows results slowly and needs hundreds of hours of treatment to be effective. That is, it needs commitment and motivation to succeed, mainly from the guardians and, of course, from the child treated. According to Evans (2022a) patient collaboration is the most critical in treatment success, as amblyopia, strabismus, and occlusion therapy affect patient’s seeing and psychological function. Vagge and Nelson (2017) address compliance to occlusion in their review article and note that educational support for the parents and patients to understand the importance of patching accompanied with written information increases compliance with patching. Other weaknesses of patching are that it may lead to reduced binocular vision and stereopsis and psycho-social problems, for example, loss of self-esteem has been reported (Levi, 2020). According to Evans (2022a), there is evidence in one study for and two against occlusion therapy distressing children.

According to McConaghy and McGuirk (2019), as a *pharmacologic treatment*, a mydriatic eye drop called atropine 1% is used to cause temporary paralysis of accommodation and dilation of the pupil resulting in a blurred image of the non-amblyopic eye and inability to focus on near subjects. Besides that, it stimulates the preferential near fixation of the amblyopic eye resulting in subsequent visual improvement (McConaghy and McGuirk, 2019). By forcing the amblyopic eye for near fixation, the non-amblyopic eye can still focus on far distances (Levi, 2020). According to Bowling (2016), atropine is an alternative method to occlusion and may work best in moderate amblyopia. Moderate amblyopia is defined by visual acuity in the amblyopic eye between 20/40 to 20/80, and severe amblyopia is from 20/100 to 20/400 (McConaghy and McGuirk, 2019). In a randomized trial by Scheiman et al. (2008), patching was compared to atropine in children aged 7 to 12 years. The results showed that both treatments led to similar degrees of improvement with moderate unilateral amblyopia. Similar results were gained in a follow-up to the clinical trial from Repka et al. (2014) and in the article from Chen and Cotter (2016). Both occlusion patch and atropine treatments were well tolerated, and only a slight difference was reported in acceptability with atropine treatment, according to Chen and Cotter (2016). Systematic side effects, such as dryness, flushing of the skin, fever, confusion, unusual behaviour, and irritability rarely occurred (Chen and Cotter, 2016).

Chen and Cotter (2016) presented that the Bangerter filter can be used as *an optical penalization treatment*. In the Bangerter filter treatment, a translucent filter of different degrees of image defocus is applied to a spectacle lens aiming to degrade the non-amblyopic eye's visual acuity. The treatment is for full-time wear and can be considered for patients who did not manage to comply with patching or atropine treatment. On this treatment, parents have reported better compliance and fewer adverse effects than with patching. For its disadvantages, the filter is not a peek-free option, and it might not uniformly degrade visual acuity as predicted by the manufacturer (Chen and Cotter, 2016). One treatment plan based on the gathered information above for functional amblyopia is presented in figure 1.

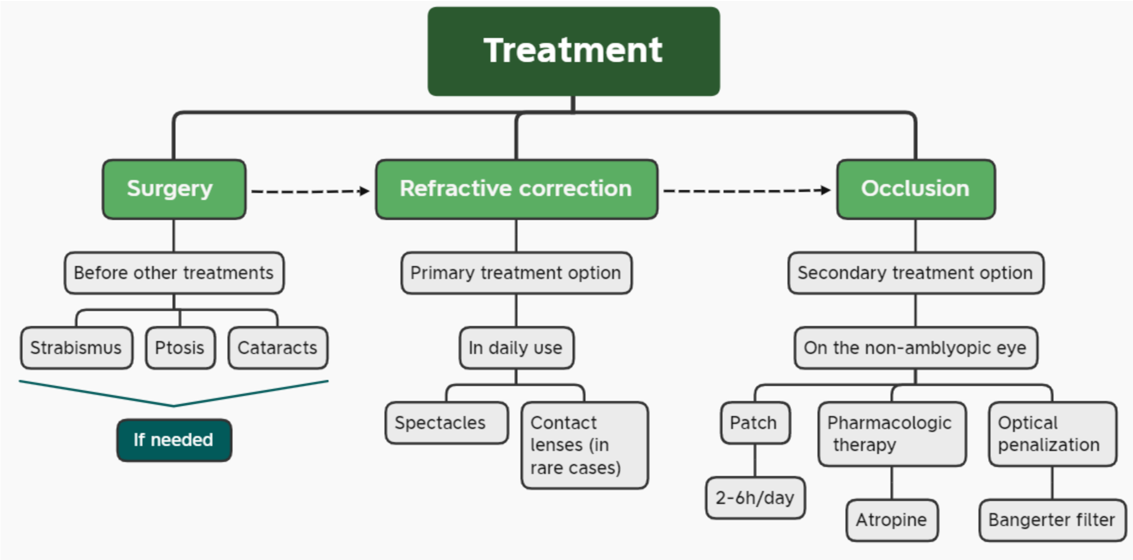

FIGURE 1. The treatment options for amblyopic patients.

2.4.3 Other Treatment Options

There are a few other treatment options such as perceptual learning and playing videogames, that focus on monocular and binocular training (Kraus and Culican, 2018; Levi, 2020). Even though these methods have been giving promising results, they are not yet widely in clinical use due to the lack of randomized clinical trials thought by Levi (2020) or lacking long term follow-up wonder by Kraus and Culican (2018). According to Boniquet-Sanchez and Sabater-Cruz (2021), with interest and advances in technology, various treatments for patients with amblyopia have been developed. They state that the interest in using interactive devices as a form of treatment has been on the rise among researchers and physicians. The goal of binocular therapy is to enhance the visual acuity of the amblyopic eye and regain binocular fusion and stereopsis. These approaches are called dichoptic treatments, which are based on visual tasks that can only be solved when both eyes cooperate, Boniquet-Sanchez and Sabater-Cruz (2021) sum. When enhancing the visual acuity of the partially sighted eye through movies or video games, some require special glasses like polarized or red-green anaglyphic glasses, and some rely on low-pass filters to reduce luminance in one eye (Boniquet-Sanchez & Sabater-Cruz, 2021). Boniquet-Sanchez and Sabater-Cruz (2021) also conclude in their article that since technological progress in recent decades is immense, it will lead to improved amblyopia management that focuses on treating binocularity. They also note that further research on the subject is needed.

2.5 Screening and Controlling Amblyopia in Finland

In Finland, vision and, therefore, amblyopia is screened in child health clinics by general practitioners and public health nurses, and referrals for more advanced examinations are sent to the nearest residential area hospital's ophthalmology outpatient clinic. The screening is implemented through specific guidelines nationwide found in the electronic database for medical staff called Duodecim. According to the database, screening is performed at age-linked controls starting from newborns and continued when the child is 4-6 weeks, four months, 8 and 18 months, three years, and after that, every year until the age of six. After that, screening continues in schools. These visits cover extensive ophthalmic examinations, including, for example, external inspection of the eyes and lids, pupillary and red reflex tests, an account of the family's ocular history of amblyopia and refractive errors, vision assessment, visual acuity testing for far and near, gaze fixation, Hirschberg test, cover-uncover test and test of eye-hand coordination (Seppänen, 2021).

According to Dr. Liinamaa from Oulu University Hospital, examinations at the hospital are performed in collaboration with ophthalmologists, optometrists, and nurses. The diagnosis, treatment, and follow-up plans are made by an ophthalmologist. Follow-up visits can include nurse or ophthalmologist visits or both. Follow-up plans are based on the age of the patient and the severity of amblyopia. Mainly, the nurse controls include the study of visual acuity to detect whether the chosen form of treatment has worked. Also, the binocular function is tested regularly. In addition to that, guardians are interviewed on how successful the implementation of the treatment has been, and if necessary, treatment mode is changed (Liinamaa, 2022a).

In Finland, treatment of amblyopia is discontinued in most cases by the eighth year of age in public health care, as the benefits of treatment decrease significantly. However, in some cases, the treatment is recommended for a more extended period, especially in cases where amblyopia was diagnosed late (Liinamaa, 2022a).

2.6 Digital Services in Eye Health Care

The restriction and lockdowns of the COVID-19 pandemic have boosted communities to rethink and reinforce hospital visits, screening, and follow-ups, and one solution has been virtual visits (Summers et al., 2022). Already before the lockdowns in Finland, different healthcare units of hospital districts have put effort into digital care pathways to complement traditional healthcare. It depends on the hospital district what digital pathways are opened for the patients (Health Village, 2022a). The platform for these digital care pathways is located on Healthvillage.fi-pages. The Health Village service unit was produced in the Virtual Hospital 2.0 project coordinated by Helsinki University Hospital and as a joint project set of all university hospital districts in Finland. The project started in the year 2016 (TerveyskyläPRO, n.d.-a). In the care pathways, the patient or caregivers can, for example, fill in surveys related to treatment and receive feedback, find patient instructions, communicate with those responsible for treatment remotely or via messages, and send follow-up information from health check-ups. These digital care pathways are available to care for and support many different health conditions, for example, diabetes, depression, MS disease, premature infant, rheumatoid arthritis, and sleep apnea. In eye healthcare, there are few pathways existing for glaucoma care and dry eye (Health Village 2022a). To use the service, the patient must log in using a mobile certificate, Finnish online banking codes, or an electronic ID card. When a guardian logs in to a child's digital care pathway, it is possible to log in on behalf of someone using their own identification, as mentioned ahead. The digital care pathways are free for the patients and open 24/7. The Health Village also provides a platform for remote appointments via video connection and self-care programs to help improve one's health. (Health Village, (n.d.-b).

For The Northern Ostrobothnia Hospital District, Autio and Kinnunen (2016) developed a service chain for a digital platform in glaucoma care. The care pathway responds to the problem where the patients' monitoring data on intraocular pressure, gathered from private practice, are not transmitted through control visits unless the patients carry the documents with them. The pathway improves the service chain between primary and secondary healthcare for better patient monitoring and welfare (Autio and Kinnunen, 2016).

This type of digital care pathway for treating and monitoring amblyopia does not yet exist, but there is a need in The Northern Ostrobothnia Hospital District. Therefore, this study aims to create a digital care pathway to answer that need. Next, chapter 2.6.1 explains how digital services could be a part of controlling amblyopia.

2.6.1 Potential of Digital Services for Controlling Amblyopia

At the Ostrobothnia's hospital district, the information about amblyopia (causes, treatment, and follow-up) is dispersed in printable forms and on websites. The contact channel, using traditional phone call methods, is also a challenge during office hours. Also, the control visits for a visual acuity check-up are resource-binding and both time and cost-consuming for patients traveling long distances. Healthvillage.fi can already provide a working platform for all of these, but controlling visual acuity raises the most significant issues when the hospital does not yet have its own software for examining visual acuity remotely.

Options for testing visual acuity outside the clinic are limited to paper charts, smartphone applications, and web-based tests (Bellsmith et al., 2022). There are already several visual screening applications for the pediatric population serving telemedicine needs (Bastawrous et al., 2015a; Yamada et al., 2015; de Venecia et al., 2018; Silverstein et al., 2021). Nonetheless, validated visual acuity assessments conducted at home are yet to be few (Steren et al., 2021; Bellsmith et al., 2022). According to Birch et al. (2022), testing visual acuity at home is challenging, despite modern technology, because it still requires accurate viewing distance measurement and close attention to the size of the optotype. One concern Birch et al. (2022) raises from the home testing with printed charts is that most of them lack the crowding bars, there is no progression of letter size, and there is a possibility to memorize the chart as most of them have only one version available.

Bellsmith et al. (2022) validated three at-home vision examination methods: paper chart, smartphone application, and web-based test. Their study found that all three at-home self-administered visual acuity tests were valid within one line of in-office Snellen acuity, and there were no statistically significant differences between the tests. Test participants considered all three tests easy to use and expressed interest in future home testing. However, according to feedback, Bellsmith et al. (2022) thought that participants did not want home tests to replace in-office acuity testing because of concerns about the accuracy of the tests. Based on the results, Bellsmith, et al. (2022) estimated that visual acuity measurements performed at home would work best to ensure no significant change has occurred.

Birch et al. (2022) tested one web-based visual acuity test called M&S EyeSimplify At-Home Visual Acuity Tests for the pediatric population implemented at home. They found it to have excellent concordance with the in-office testing. They also consider this type of test to provide the information needed to continue care if the burden of travel is significant. Also, a significant notation from Birch et al. (2022) in their study was that it is advantageous to use the ATS-HOTV and E-ETDRS visual acuity tests in telemedicine because those adhere to the American Academy of Ophthalmology recommendations to use single optotype with crowding bars and have a logMAR progression of optotype size. The crowding optotypes are also beneficial, as they should not overestimate visual acuity in children with amblyopia. (Birch et al., 2022).

According to Ritchie et al. (2021), validity and reliability of vision testing using apps by non-healthcare professional video consultation is useful for external eye examination and symptom enquiry, and to examine the visual acuity or other clinical investigations additional software and instruments are needed. As reported by Ritchie et al., 2021 the validity and reliability of testing visual acuity with an application by non-healthcare professionals in an at-home setting have not yet been attained. Several uncontrolled variables exist in the accuracy of the visual acuity result tested by a parent, guardian, or the patient him/herself, even with clear instructions. Such variables include for example changes in viewing distance and unnoticed peeking (Ritchie et al., 2021). Painter et al. (2021) examined whether parents can test their child's vision at home using vision testing apps Peek acuity or iSight Pro and aimed to find out opportunities for a telephone consultation. The test was conducted during Covid-19 lockdowns. The sampling was small (n=103), of which 15 families conducted the experiment, and in overall, most parents felt it was easy to take the test. A third of the parents thought it was difficult to test the child, and half felt that keeping the child's concentration was challenging. In the results, the visual acuity of the home tests was slightly better (0.14 LogMAR), and the test-retest result was 0.03 LogMAR. Their study highlights the possible risk factors for home testing, as from 103 families, 96 agreed to participate, but 81 of them were unable to provide results. Reasons (n=50) for this included, among other things, an inability to receive instructions via email, inability to understand the instructions, being too busy to undertake the test, and reluctance to download the application. The families who did not receive the instructions via email were verbally guided to find them from the hospital intranet but still did not complete the test. (Painter et al., 2021). Painter et al. (2021) see the possibilities of checking visual acuity at home. Still, they consider optimizing parents' experience with application technologies essential and it should be used as a basis for developing applications. They also contemplate that clinician-led home vision testing on a videoconferencing platform may be appropriate in some circumstances, allowing better test control.

To conclude, there is potential in digital services for controlling amblyopia. A platform where the latest and most important information according to amblyopia is shared with parents and children required to engage them in care and control could positively affect the treatment of amblyopia. However, there is not yet existing tool that could be reliably and validly used for at-home visual acuity testing for amblyopic patients in Finland. On the other hand, Healthvillage.fi service could be used to share the results of visual acuity testing done for example by the local optician, as it is done in the digital care pathway for glaucoma patients (Autio and Kinnunen, 2016).

2.6.2 User Experiences with Digital Care Pathways

As previously mentioned, multiple digital care pathways are already complementing the traditional healthcare in Finland. A new study examined the implementation of digital care pathways from a personnel point of view. In this study from Keveri (2022), the staff were mainly satisfied with the digital care pathway and its usability. The results showed that the commissioning process was mostly perceived to be easy. Employees interviewed for the study also highlighted the functionality of the digital care pathway's message section. They also felt that patients' attitudes towards the service were positive and that patients were satisfied with the content of the pathway (Keveri, 2022). In the study from Merioksa (2020), patient satisfaction towards the digital care pathway was explored in gestational diabetes, and it was positive. The survey also revealed the wish of a few respondents that the digital care pathway should also be used in a counselling clinic, which would reduce patients' recording need for blood glucose values to paper and platform (Merioksa, 2020).
These studies are positive examples of working digital care pathways. They also provide good improvement ideas for the future digital care pathways.

3 THE PURPOSE, OBJECTIVES, AND TASKS OF THE RESEARCH DEVELOPMENT WORK AND OF THE DIFFERENT STAGES

3.1 Purpose of the Study Statement

The purpose was to gather all the relevant information about amblyopia for the patient and their guardians in one place and to create an accessible contact channel for the patient. At the same time, efforts were made to find reliable methods for controlling visual acuity remotely.

3.2 Statement of the Research Question

How can a digital care pathway for amblyopic patients be implemented in the Northern Ostrobothnia's hospital district?

3.3 Summary Description of the Experimental Design

This thesis was a development project, and the theoretical background was implemented as a descriptive literature review. Results of the literature review were used as a basis of the digital care pathway for amblyopia in The Northern Ostrobothnia Hospital District. The care pathway was developed with cooperation of the Oulu University Hospital and The Health Village. The development project included the design and script of the digital care pathway. As part of the project, through the literature review, this study also explored the possibilities of remote visual acuity control. Furthermore, the digital care pathway was created according to the model of development of the Health Village (TerveyskyläPRO, n.d.-c). The development of the digital care pathway includes four steps: 1. *planning* including preliminary evaluation, survey the situation, design and specification stages, 2. *content production*, 3. *implementation* and 4. *maintenance and further development* (TerveyskyläPRO, n.d.-b). This project included faces one and two, including the script of the digital care pathway. This study did not cover the implementation, that is, the testing and validation of the pathway, nor the maintenance and further development phases. The model of construction of the digital care pathway and the part of the development project are subscribed in figure 2. Further studies about the subject and final decision and implementation on opening the digital care pathway for amblyopia remain with the hospital district.

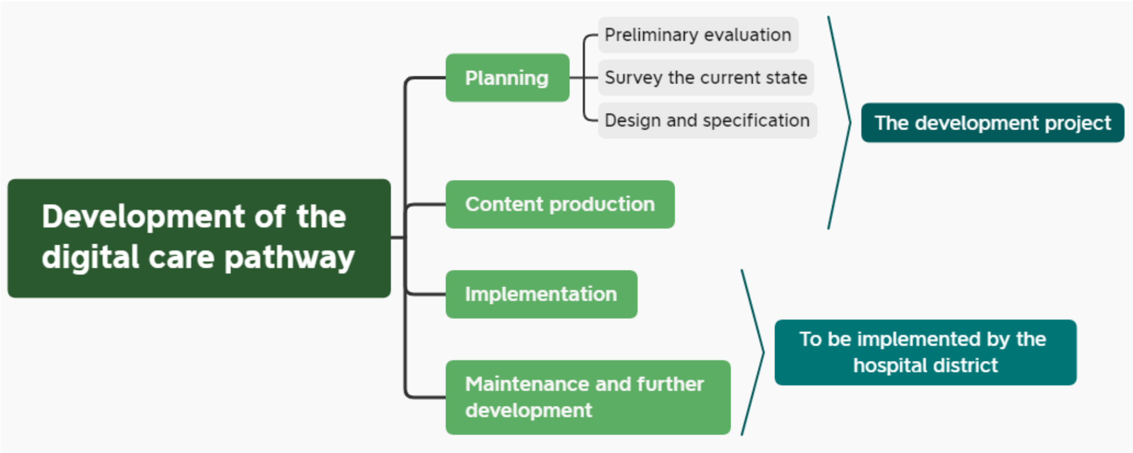

FIGURE 2. The model of digital care pathway construction of the Health Village and part of the development project

3.4 Study Objectives

The research question was answered through four specific objectives:

1. Explore the opportunities of the Health Village platform for the implementation of the amblyopia digital care pathway.
2. Gather, summarize and simplify relevant information about amblyopia to be available for amblyopic patients and their guardians in the digital care pathway.
3. Explore the available applications for remote digital visual acuity measurement.

These first three objectives contributed to reaching the fourth objective of this development project, which was to

4. Develop a digital care pathway for amblyopic patients.

4 IMPLEMENTATION OF THE RESEARCH DEVELOPMENT WORK

4.1 Methodology

The first three objectives of this project were research-based and thus, were pursued as a descriptive literature review. Salminen (2011) states that a descriptive literature review is an overview without strict and precise rules. The data used are not bounded by methodical rules. In a descriptive literature review, a qualitative synthesis of results is made (Salminen, 2011). In this development project, the synthesis of results was made to build an overall view of amblyopia, its treatment, and follow-up options to be used as information in the digital care pathway for amblyopia (objectives 1, 2 & 3). Furthermore, the literature review served as the main source of information for conducting the actual development work (objective 4), which was implemented in three stages namely preliminary evaluation, design and specification, and pathway construction, following the model of development of the Health Village.

To complement the information needed especially for the objectives 1 and 4, the author of this development project spent time in the organization that commissioned the work. During the visit, the author took notes and surveyed the needs of employees about what the digital care pathway would be suitable to contain in terms of information and functions. The author also mapped out frequently asked questions (FAQ) for the contact section of the digital care pathway. Additionally, personal information related to the topic was received from ophthalmologist Dr. Johanna Liinamaa, optometrist Anna Autio and Kirsi Tuomikoski, the service manager of The Health Village at the Oulu University Hospital.

4.1.1 The Literature Search and Literature Review

Related studies and articles on the subject were searched from electronic databases called PubMed, Google Scholar and Duodecim. Professional literature was also included. In addition, training material from The Health Village and their website (https://www.terveyskyla.fi/en) were used as a source of information. A literature search was performed from spring to autumn 2022, and studies were included according to relevance to the subject in an effort to use as new information as possible. Search terms were used based on the specific subject of the theoretical background. Search terms were from wide range, and for example ”amblyopia treatment”, “amblyopia diagnosis”, “amblyopia binocular vision”, “amblyopia visual acuity test”, “amblyopia stereoacuity”, “amblyopia control”, “telemedicine AND amblyopia”, “remote visual acuity test AND amblyopia”, “visual acuity smartphone” were used.

4.1.2 Two Stages of The Development Work

In the development project, it was identified, in collaboration with the organisation, what were the needs for the digital care pathway of amblyopia. There are ready steps to produce a digital care pathway in The Health Village, which are described in figure 2. This study included the first two stages prescribed in more detail in table 1. The first phase of the planning included the preliminary evaluation, survey of the current state, and design and specification stages. A research plan was conducted, and the development project fully started after approval from the hospital and thesis supervisors. As explained earlier, a visit to the organization was needed to survey the current state of the amblyopia care path. The design and specification stage started with planning the schedule and describing the target state. It was planned with the project team, consisting of the author of this thesis, contact persons from the organization and The Health Village. The design and specification stage also included writing a project card, risk analysis, and cost-benefit statement. These were made in collaboration with the organization's contact person. The author of this thesis gathered the content for the digital care pathway through the literature review from the project start to the end of the design and specification stage. After the literature review, the digital care pathway's final stages included content production starting with drafting the manuscript for the digital care pathway. Then, the content was reviewed and approved by the organization and The Health Village. Finally, the content was entered into the digital care pathway template.

4.1.3 Cooperation and Timeline

This topic for the master’s thesis was suggested from the Oulu University Hospital. The Student (the author of this thesis) assigned to the Contractor (Oulu University Hospital) all financial copyrights related to the thesis and its results. The Contractor has the right to assign the rights to a third party without consulting the Student and to make any changes necessary for dissemination and making available to the public. Neither the student nor the Oulu University of Applied Sciences received financial support for conducting the study. The Contractor has assigned parallel access to the thesis and related material to Oulu University of Applied Sciences without compensation. The license includes the right to preserve the thesis and related material and to use it in teaching and research activities, library services, presentation and marketing of its activities, and other normal activities.

The development work started at spring 2022 and was planned to be implemented by the end of the year 2022. The timetable for the development project is presented in *table 1*.

TABLE 1. Timetable of the development project

Development project stages in a timeline			
	Operation	Participants	Production
12/2020	Idea of the digital carepathway for amblyopia	Superior of the pediatric ophthalmology unit of Oulu University Hospital	Preliminary evaluation
4/2021	Discussion of the possibilities in implementing the digital pathway by a masters thesis	Oulu University of Applied Science supervisor and student	Preliminary evaluation
2-3/2022	Implementation of the research plan	Student, hospital supervisors, Oulu University of Applied Science supervisor	Preliminary evaluation
4/2022	Innovation project start	Student, hospital supervisors	Preliminary evaluation
6/2022	Visit	Student, hospital supervisors and staff of the eye clinic	Survey of the current state
6/2022	Timetable planning, describing the goal state	Project group and the Health Village project group (Digital Care Pathway development model)	Design and specification stage
5-10/ 2022	Literature review for the content of the Digital Care Pathway	Student	Content production
9-10/2022	Project card, risk analysis, cost benefit statement	Hospital supervisors and student	Design and specification stage
9-10/2022	Drafting the manuscript for the content	Student and hospital supervisor	Content production
11/2022	First review, plan approval	The Health Village project group, hospital supervisors and student	Content production
11-12/2022	Content entering to the Digital Care Pathway template	Student and hospital supervisors	Content production

4.1.4 Reliability of the Research Development Work

The reliability of the project was ensured through comprehensive and careful planning. Careful considerations were made in the literature search and qualified reliable sources were chosen for the theoretical background. Throughout the research process, regular meetings were held with the collaborative organisation. The reliability of the research was also improved by the involvement of two experts from the field of the organisation. One of them has strong experience in developing digital care pathways and in guiding the care of children with amblyopia and their parents. The other expert has a strong understanding and knowledge of amblyopia and long experience as a clinical ophthalmologist in amblyopia. She also carries out ongoing research work in addition to her clinical work. To improve reliability, comprehensive notes were taken from both the meetings and the organisational visits so that the work could be reported accurately. Project stages were reported transparently, and the final outcome was evaluated with the collaborating organisation.

4.1.5 Ethicality of the Research Development Work

In this research, the research integrity guidelines of the Finnish Advisory Board were followed. The research has been carried out in accordance with the basic principles of research integrity which are reliability, honesty, respect and accountability. The implementation and rights of the thesis were agreed with the organisation that commissioned the work before the project started, and an appropriate written agreement was conducted for the execution of the work, as mentioned earlier. The work of other researchers was valued and respected by referring to the original publications. The names of the researchers and collaborators who made significant contributions to the study have been honoured by mentioning them in the thesis. Permission from the Institutional Review Board was unnecessary as no human subjects were used in this study. (Finnish Advisory Board on Research Integrity, 2023).

4.1.6 Evaluation of the Research Development Work

In the research, well-defined, clear and precise objectives and targets were made. While doing the research, the objectives were carefully observed and together with the organisation, it was ensured that the work met their needs. A limitation of the project was that the digital care pathway was not validated, as it was originally agreed with the organisation, but therefore it was not possible to assess the functionality of the digital care pathway. However, the work within the organisation will continue, and they will be able to improve the pathway after testing and validation. The values of the study were that the objectives were fulfilled, and the project commissioner was content.

4.2 Specific Aim 1

The first specific aim was to explore the opportunities of the Health Village platform for the implementation of the amblyopia digital care pathway.

4.2.1 Methods

The Health Village had many opportunities for individual services to be opened for a particular digital care pathway. When using a ready platform of The Health Village, the steps on how to proceed in the actual care pathway became ready on the behalf of The Health Village. As a basis for opening a digital care pathway in The Health Village, project included a reflection on the goal and benefits of the digital care pathway, risks, and their management, as well as a description of the current state and goal status from the patient's and professional's perspective. This was accomplished by visiting Oulu University Hospital in the department of pediatric eye care to monitor the reception of nurses and ophthalmologists. A discussion of the current care pathway was made with the unit’s staff, as well as ascertaining the wishes of the cooperative entity for the target state of the digital care pathway.

4.2.2 Results

The current amblyopia care pathway. The screening phase and the amblyopia suspicion is done at child health clinics by a general practitioner, a pediatrician or a nurse. Then child is referred to ophthalmologist to the pediatric ophthalmology unit. Where the child is examined, and diagnosis is made (Seppänen, 2021). Therefore, in general, the treatment path for amblyopia includes the following steps. The ophthalmologist examines referrals at the pediatric ophthalmology unit, and an appointment is made with the unit. The child first arrives at the nurse's office, where, depending on the child's age, a range of vision tests, including visual acuity measurement and binocular single vision tests such as stereotest, a function of the eye muscles including manifest and latent strabismus. Finally, the patient is dosed with eye drops that dilate the pupil and weaken the accommodation, with a waiting time of approximately 30 minutes. After that, the patient is examined by an ophthalmologist who will make a diagnosis and design a treatment and follow-up plan. Continuing with the implementation of the treatment plan is carried out with the nurse. Meaning, for example, guidance and tips on occlusion therapy. The patient and guardians receive a fact sheet on amblyopia, which also contains the clarification of the therapies and tips on their implementation. After visiting the clinic, the patient receives a financial commitment by mail to purchase spectacles. Also, according to the control interval instructed by the ophthalmologist, the next date for control arrives via post. The patient can only contact the clinic secretary or nurse by phone. According to Dr. Johanna Liinamaa, on behalf of the hospital, calls to the pediatric ophthalmology unit were followed in the autumn of 2022 for two weeks, and 30 calls were registered, excluding the calls for booking an appointment. The calls ranged from 5 to 30 minutes, with an average of about 15 minutes. After the call, the nurse writes the agenda for the patient management system. This small survey did not measure the time taken to record the caller's agenda. According to follow-up and the unit's nurses and ophthalmologist the most common contact topics include implementing occlusion therapy, renewal of prescription (eyedrops), purchasing spectacles, or making an appointment. Some calls require the consultation of an ophthalmologist (Liinamaa, 2022b). Controls designed by an ophthalmologist are individual and may comprise either ophthalmologist or nurse control. In the case the control is carried out by a nurse, they most often include the measurement of visual acuity and an interview with the patient's guardian about the implementation of the treatment. However, when necessary, the controls also include other visual tests. The current patient's care pathway is described in figure 3.

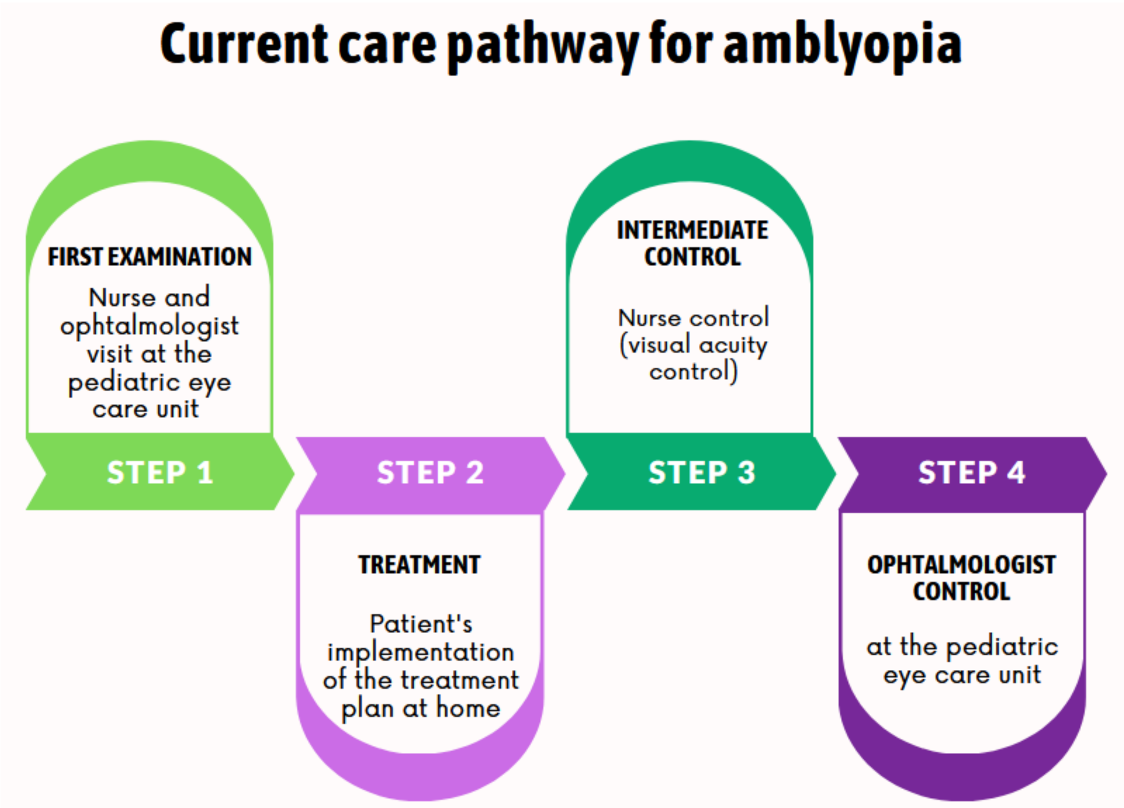

FIGURE 3. Current care pathway for amblyopia.

The digital care pathway in the amblyopia treatment and control. When the treatment is started, the visual acuity needs to be controlled as it is kept a mark of the success of the treatment as stated by Birch (2013). The visual acuity control may not need an actual visit to the pediatric ophthalmology unit, giving an opportunity for digital services. And if the visual acuity is not as good as hoped, an appointment with the ophthalmologist is made. Therefore, from the current treatment steps, step 3 could be implemented digitally through the existing Health Village service. In addition, all paper releases could be implemented through the digital care pathway.

The digital care pathway could include both the appointment booking and communication between the patient and the clinic. Electronic appointment booking would free up the secretary's time if a paper appointment were given up. Also, the digital platform could enable patients to change the timing of their appointment, if needed. A digital care pathway would also be an excellent contact channel that does not bind the patient's contact time to agency hours. The corresponding party, namely the secretary and nurses, can also respond at a convenient time. There will be no additional ringing if the patient is not caught or the other way around, saving both patient and respondent time while freeing up resources. The nurse may also easily direct the question to the ophthalmologist via digital care pathway, making the response chain work faster and less interrupted. When a specific time of the work shift is planned for the answer, the work will also remain more uninterrupted, enhancing the management of the nurse's and the ophthalmologist's work. More specifically, the nurse does not need to interrupt work due to the call or when the nurse can direct the sent message via the digital care pathway to the ophthalmologist directly; also, the ophthalmologist's work will be less interrupted. According to The Health Village, one can create ready-made phrases for the digital care pathway, speeding up the response process (Tuomikoski 2022). And as specific questions on the patients' behalf recur, the platform also allows a FAQ section that may answer the patients' needs without additional questions. The digital care pathway also allows videos, so if, for example, a help video is made on the implementation of occlusion therapy, it helps the patient’s parents implement the treatment. In addition, it may reduce the time from the nurse’s first visit (step 1, figure 3).

Therefore, based on this development project, the intermediate control phase (step 3) is recommended to be implemented through the digital care pathway. Furthermore, the digital care pathway can be used actively throughout the treatment period as an information and communication channel between the patient and clinic. The Health Village enables this well because it includes filling in surveys related to treatment and receiving feedback, finding patient instructions, communicating with those responsible for treatment remotely or via messages, and sending follow-up information from health check-ups. (Health Village, 2022a). Thus, although the step 2 itself does not change in the new model, the digital care pathway enables an easily accessible way for the patients to, for example, ask help and contact the clinic if they come up with questions or concerns during the treatment period at home. Steps 1 and 4 are more comprehensive nurse controls cannot be implemented in the digital care pathway as the examination needs physical contact. Also, this was not the hospital district's aim. Furthermore, there is no risk of interruption of treatment. Suppose the patient's parent is not joined to the digital route for one reason or another. In that case, the patient's treatment will continue normally as it is currently implemented and described in figure 3.

4.2.3 Discussion

Based on the results, digital eye care services can be used as a part of the care pathway of amblyopic patients and could work well as there is an existing available digital care pathway platform called The Health Village (Health Village, 2022a). According to Autio (2022), one identified challenge in using the digital care pathway for glaucoma has been the age of the users, as the disease affects mainly aged people (Autio 2022). However, this might not affect the amblyopia pathway, as mostly the guardians of amblyopic patients are at a certain age and are accustomed to the use of technology in their everyday lives. In Finland, the digital tools are highly developed and used extensively for example in banking services. Banking services are mainly performed online and through a telephone application. Online banking IDs are also used to identify yourself into several other services, such as prevalent online purchases, so logging into the digital health care services would be easy with the already existing tools. In Finland, almost every household has a smartphone, tablet, or computer, and Finland's mobile network is extensive, covering nearly the entire country. Also, all libraries have access to computers and the internet. When these resources are considered, the digital care pathway for amblyopic patients would improve the accessibility of the services regardless of time and place of resident.

When implemented, the digital care pathway would reduce the patient's need for physical visits, which is especially useful if the patient travels from a distance. As mentioned earlier, The Health Village provides a platform for remote appointments. If this possibility is taken into practice to examine the visual acuity, it will save the resources. For example, one does not need an examination room to meet the patient. The meeting can be implemented in a smaller and less equipped room, releasing the examination room for someone else's use. Along with the contact channel, the accessibility of the specialist improves at the appropriate time for the patient. More accurately, when sending the question is not tied to time, one can ask it anytime, and when getting the answer in writing, one can get back to it whenever. Of course, in more urgent matters, traditional calling is also an option. At that time, the accessibility is also improved when some unurgent calls are absent, and nurses have more time to respond to the urgent ones.

The limitation of this project is that information about the use of the service was not collected from staff or guardians. Therefore, the user experience could not be fully established. However, the previous studies have revealed mainly positive attitude towards digital care pathways and their usability from the personnel point of view (Keveri, 2022), which gives promises that also amblyopia care could benefit from the digital care pathway. In the study by Keveri (2022) the personnel highlighted the functionality of the digital care pathway’s message section. However, it is essential to pilot the digital care pathway to see if it is functional, for example, are the pathway steps clear for the user and if additional functions are needed. Accumulating user experience is part of the implementation phase of The Health Village's development model, where new operations are practised by a small group of patients and professionals for a few months.

As digital care pathways are not yet widely used for monitoring and screening other eye diseases (Health Village, 2022a), their possibilities are yet to be seen. One possibility could be in providing care and control, for example, in dry eye syndrome more widely, or for conditions that require regular monitoring. Today, for example the patients with cataracts or dry AMD rely on self-monitoring, and digital care pathways could provide a platform for them to write down and keep a record of the state of their vision in one, safe platform. When they perceive changes that require a visit to a clinic, the self-monitoring data would be easily accessible for the ophthalmologist. In addition, optometrists’ expertise could be used to assist the monitoring of these kind of conditions, for example, with visual acuity testing, Amsler grid follow-ups, and fundus and OCT imaging. Today, the training of optometrists is constantly evolving, creating more expertise and opportunities for this type of monitoring and cooperation between optometrists and ophthalmologists. However, optometrists currently do not have referral rights, which makes it difficult to exploit this potential. That is, optometrists are not there to diagnose or treat the patients, but their expertise could be useful in monitoring the need for treatment. This would enable a consistent care path for the patients and timely visits for the ophthalmologists, whenever the need is recognized.

4.2.4 Conclusion

To conclude, opportunities for a digital care pathway to complement traditional healthcare in amblyopia treatment are good. A trustworthy platform called The Health Village already exists. The chances of success in the technical part of using the digital care pathway are reasonable considering the age of the users' guardians.

4.3 Specific Aim 2

The second specific aim was to gather, summarize and simplify relevant information about amblyopia to be available for amblyopic patients and their guardians in the digital care pathway.

4.3.1 Methods

The assignment was to produce up-to-date content from amblyopia with the literature review and to give propositions to the content. The aim was to summarize and then simplify the theoretical information into a usable form for the digital care pathway's manuscript. As mentioned in the methodology section 3.5, I visited the pediatric ophthalmology unit. During the visit, I took notes and surveyed the needs of employees about what the digital care pathway would be suitable to contain in terms of information and functions. I also surveyed FAQs for the contact section of the digital care pathway from the nurses and doctors of the unit having years of experience in the subject. Also, the staff was helpful with tips on how to motivate the child in treatment. The currently used information leaflet, distributed to the amblyopic child's guardians, was also used as a source for tips-section implemented in the "treatment plan" on the digital care pathway.

4.3.2 Results

As a result, thematic areas were identified on which information is needed for the digital care pathway: What is amblyopia? Why is it important to treat it? What are the different therapies and side effects? How can one engage and motivate a child to treatment? When examining previous digital care pathways, it was noted that FAQs are a valuable addition to the digital care pathway, as specific questions recur and can congest the digital care pathway's contact channel. This is an additional section to the digital care pathway's contact channel. As the content in the actual digital care pathway is in Finnish, a summary of the information topics along with examples of the simplified information is presented in English in table 2.

TABLE 2. Examples of the information provided in the digital care pathway.

Topic	Subtopics	References	Example of simplified information
Basic information about amblyopia	Development of the vision	(Bowling, 2016; Evans, 2022a)	Vision develops most during the first two years of life, but visual acuity continues to develop until around the age of ten. Only during this period can we address the visual problems caused by amblyopia. This is why early and effective treatment is of paramount importance.
	Amblyopia aetiology	(Bowling, 2016; Evans, 2022a; McConaghy & McGuirk, 2019)	Amblyopia, or functional amblyopia, is most commonly caused by strabismus or a large refractive error between the eyes. These can cause the child to use only the better-seeing eye for looking. The brain automatically erases the image formed by the poorer eye, resulting in a further loss of vision in the poorer eye, which may be lost altogether. Other causes of amblyopia can also include severe astigmatism, pendulous cataracts, congenital cataracts, or corneal clouding due to various causes.
Patient instructions	Treatment and Follow-up	(Birch, 2013; Chen & Cotter, 2016; Evans, 2022a; Holmes et al., 2001; Levi, 2020; McConaghy & McGuirk, 2019)	Treatment of amblyopia depends on the cause. The most common treatment is spectacles and, if necessary, treatment is combined with/often requires the use of occlusion. If, for whatever reason, occlusion cannot be applied, amblyopia can be treated with an eyedrop (atropine) or special glasses (penalisation). Sometimes, when amblyopia is caused by strabismus, it can

			also be treated by surgery if other treatments are not sufficient or appropriate. The earlier the treatment is started, the more effective it is.
Contact	FAQ	Survey FAQs from the hospital staff	Q: Can amblyopia be corrected as an adult with refractive surgery? A: Amblyopia cannot be corrected by refractive surgery as an adult. In the case of a growing child, vision changes every six months or more and corneal surgery cannot be performed repeatedly.

4.3.3 Discussion

The information on amblyopia must be in one place that is easily accessible and in an understandable format for the children and their guardians. Therefore, it is essential to include educational information in the digital care pathway; as noted by Vagge and Nelson (2017), that educational support for the parents and patients accompanied by written information increases compliance with pathing, one of the treatment options for amblyopia. It is also essential that the data is based on the latest research knowledge, as it is now in my literature review. Seven years ago, the article by Chen and Cotter (2016) concluded that there is an increasing interest in enhancing binocularity in amblyopia treatment, but no significant changes have yet occurred. The practice of binocular vision and using video games in amblyopia treatment are still discussed as modern therapies that have yet to be widely adopted as they require more research (Boniquet-Sanchez & Sabater-Cruz, 2021; Kraus & Culican, 2018; Levi, 2020). These therapies may play a more significant role in the near future, potentially motivating children to treatment. This could potentially improve the compliance of the patients, which is, according to Evans (2022a), one of the main challenges in amblyopia treatment. Nevertheless, more research is also needed on the impact of near work on the treatment of amblyopia. Nowadays, near work has increased, and children play and watch videos on mobile phones a lot, so the benefits of video games could be combined with near work, which is unlikely to harm the child at least. Sure, another near-watching than just screen-involved is good to practice, and one must consider the daily screen time. Since this thesis focused on trusted and widely researched information to enter content into the digital care pathway, modern treatment methods cannot yet be included in the digital care pathway. However, updating the information on treatment and follow-up is essential and made now easier when the data is in digital form on the digital care pathway.

4.3.4 Conclusion

The Health Village offers a good portal for providing information that is easily accessible. Nowadays, a lot of information is available, some of which are unreliable. It is essential to direct the patient to a reliable source of information that is up-to date. This information should include explanation what amblyopia is, what are the main reasons causing it, how it is treated, and how often it should be monitored. In addition, it is important to emphasize who is responsible for the treatment and clarify the consequences if treatment is not carried out to motivate the child's guardians to care. Finally, having the information in a digital form enables regular updates of the information, which ensures that the information provided for the patients is based on the up-to-date, research-based knowledge and practices.

4.4 Specific Aim 3

The third specific aim was to explore the available applications for remote digital visual acuity measurement.

4.4.1 Methods

This aim was pursued through a descriptive literature search. The information was searched from electronic databases (PubMed, Google Scholar and Duodecim) using multiple search terms. Search terms were for example “amblyopia visual acuity test”, “telemedicine amblyopia”, “remote visual acuity test amblyopia”, “visual acuity smartphone”, “visual screening children”, “telemedicine visual acuity”, and “telemedicine visual acuity”.

4.4.2 Results

Only applications that measure distance visual acuity were selected because applications that test visual acuity to near will not meet the criteria to control amblyopia. Table 3 is presenting the applications' characteristics and the most promising ones will be discussed in more detail in the text.

TABLE 3. Characteristics of the included applications.

Application	Testing method/ optotype	Crowding	Tested with children	Availability	Validation	Charge	Calibration	Language
COMPlog	five Sheridan Gardiner letters	yes	yes	computer, laptop or tablet	(Ritchie et al., 2021; Satgunam et al., 2021)	yes	yes	English
Peek Acuity	Tumbling E Boxed	yes (a bounding box around the optotype)	yes	Android	(Bastawrous et al., 2015; de Venecia et al., 2018; Zhao, Stinnett and Prakalapakorn, 2019; Satgunam et al., 2021; Bhaskaran et al., 2022)	no	no	English
iSight Pro	Standard letters, Kay Picture optotyper	not applicable	not applicable	iOS	(Painter et al., 2021)	yes	not applicable	English
EyeChart	Snellen chart, tumbling E chart, Sloan letter chart, and Landolt C chart	yes	no	iOS	(Bhaskaran et al., 2022)	no (free version), and yes (pro-version)	not applicable	English
GoCheck Kids	HOTV, ETDRS	yes	yes	iOS, Android	(Silverstein et al., 2021)	yes	not applicable	English
Easee	Tumbling E	not applicable	no	Website, smartphone, computer/tablet	(Wisse et al., 2019)	yes	yes	English
M&S EyeSimplify	Lea symbols & numbers, Snellen Letters, Allen Pictures	yes	yes	computer, laptop	(Birch et al., 2022)	yes	yes	English

According to Ritchie et al. (2021), COMPlog is a validated PC-based visual acuity measurement system that is semi-automated and routinely used at St Thomas's Hospital in London. It is subject to a charge, and the language is English. This test is run by a professional from the hospital staff, which allows video observation of the patient. Ritchie et al. (2021) tested the software with children, of which seven were under 16 years of age and had amblyopia. Overall results showed no systematic difference between the visual acuity tested at home or in the clinic (Ritchie et al., 2021).

The Peek Acuity, developed and validated by Bastawrous et al. (2015), resulted in their study that the smartphone application is capable of accurate and repeatable visual acuity measurements. It has the Tumbling E optotype, which is, according to de Venecia et al. (2018), developed for better comprehension in non-English speaking and low-literacy population. De Venecia et al. (2018) aimed to validate the Peek Acuity mobile phone application in a pediatric population. They compared the application to a paediatric ophthalmologist examination. The research covered 393 children aged 6-16 in Paraguay. Their study showed a 48% sensitivity, 83% specificity, 43% positive predictive value, and 86% negative predictive value for Peek Acuity's ability to refer compared to a pediatric ophthalmologist evaluation. The study resulted that Peek Acuity tended to overestimate the subject's visual acuity, which caused the subject not to be sent to a more comprehensive eye examination. They stated that increased sensitivity would improve the detection of children with refractive errors (de Venecia et al., 2018). A more recent study from Zhao, Stinnett and Prakalapakorn (2019) evaluated Peek Acuity's ability to assess visual acuity in 106 children aged 3-17 years with an average age of 7.8. The result of the study was an 83% sensitivity and 70% specificity in identifying children with referable eye disease. Among 3-5-year-olds, sensitivity was 100%, and specificity 39% in identifying those with impaired visual acuity. Zhao, Stinnett and Prakalapakorn (2019) concluded in their study that Peek Acuity correlates well with visual acuity assessed by standard clinical methods, and that Peek Acuity is an adequate screening tool for those with impaired vision. Similar results were gained in the study from Bhaskaran et al. (2022), who tested the EyeChart and Peek Acuity application with the traditional Snellen chart for 184 patients above the age of 18. In addition to that, according to Satgunam et al. (2021), the Peek Acuity application was comparable with their standard clinical test COMPlog acuity, and that age or refractive error did not significantly affect the distance visual acuity.

A study by Silverstein et al. (2021) tested the GoCheck Kids application for remote visual acuity measurement. Visual acuity was measured by the patient's family member with the application and then compared to a chart, giving a modest correlation. GoCheck Kids is also in English and subject to a charge. The application is possible to download on both iOS and Android phones. A web-based program called Easee was also considered an option, as it was commonly known to be used in an optical chain in Finland for adults. This program is also subject to a charge. The program is validated, and CE marked according to Wisse et al. (2019).

4.4.3 Discussion

This literature review gives a good overall picture of remote visual acuity monitoring possibilities. In general, the applications found in the search provide good features, but also limitations that should be considered when evaluating their usefulness for remote visual acuity testing in the Finnish context. From the applications found, the Peek Acuity was the most tested application and correlated with visual acuity assessed by standard clinical methods and was comparable with their standard clinical test (Bhaskaran et al., 2022; Satgunam et al., 2021; Zhao et al., 2019). However, more research is needed before any app can be deployed, but the Peek Acuity app gives the best promises of the apps found with this search because it provides the most research and user experiences.

In terms of the good features, the most optotypes used in the selected applications were with crowding bars, which gives a more reliable effect in monitoring visual acuity in amblyopia, as Birch et al. (2022) noted. This was the case also in the Peek Acuity app. In general, the limitations include, for example, the lack the possibility of changing the language to Finnish, which is one of the most significant limiting factors. As the application is assumed to be used primarily on Finnish-speaking populations, it might need some clarification. Even though Finnish people are good with English speaking skills, it can only be assumed that some guardians are familiar with the terms used in the application. One option could be to write the directions on how to test the visual acuity with the application in Finnish with picture captures in all phases of the test. Also, the fact that some of the applications are subject to a charge limits the broader scope of their suitability on this project as it will require a different research protocol from the hospital district. Unfortunately, no application was found that is free of charge and easily downloadable for both iOS and Android-based mobile phones, which are the most common mobile phone operating systems. Suppose the application is possible to download only for one operating system. In that case, it might limit the user base, or there should be two applications in use, one for android and one for iOS. That, instead, might lower the monitoring data's reliability when the same metrics might not be used if the mobile phone changes during the treatment period. Also, all applications did not have the possibility to change the optotype of the test, which may make amblyopia monitoring more difficult by not being able to use the optotypes recommended by ATS (Holmes 2001).

Examining the visual acuity at home involves a lot of variables and concerns regarding the correctness of the results, such as correct viewing distance and optotype size, as noted by Ritchie et al. (2021) and Birch et al. (2022). Lighting also matters, as well as whether the phone's screen is kept straight. The reproducibility of the examination situation also poses challenges to the interpretation of visual acuity. Is the examination space quiet enough and as well as similar every time? Guardians may also not be sufficiently careful to assess their child's peeking. Moreover, when they share a common goal of obtaining better visual acuity, the parent may unobtrusively check the child to achieve a better result. Therefore, guardians might not be the most reliable help in the examination. This is also advocated by a study from Painter et al. (2021), which reported that some parents found it difficult to examine their own children, and time for the examination was hard to find. These may reduce the reliability of the examination, as well as reduce the child's chances of achieving the proper treatment. Paper charts share partly similar challenges. One option where these variables could be minimized is video confrontation, where a professional, for example, an optometrist, an ophthalmologist or a nurse, would submit the examination with the hospital's software as reported by Ritchie et al. (2021) to be done at St Thomas's Hospital in London. When there is no ready program for remote visual acuity assessment at the Oulu University Hospital to start right away, the examination could be implemented with a paper chart pursued with video confrontation by an optometrist or a nurse. In this case, it would be noted to consider that the paper chart would contain crowded letters when testing the vision of an amblyopic patient. When the professional pursues the examination and not the parent, it will increase the reliability of controlling the course of the examination and observing the effectiveness of the study. Whereas when regarding the possible future software, for example, Easee software could be considered with the possibility of the Finnish language. However, even in that option, there are still several things to be explored, including whether the software can be tailored for visual acuity examination for children under 18 years old. Moreover, according to Ritchie et al. (2021), The Royal College of Ophthalmologists and the British & Irish Orthoptic Society have recommended keeping accuracy in monitoring children's remote visual acuity and that such applications be used only under of a trained professional.

Based on the search, it seems that the available application options have many things that might jeopardize the reliability of the visual acuity measurement. However, since a systematic literature review was not performed in this development project, the results might not include all the available options, or some new applications might have emerged since the search was performed. Still, currently it seems that it is more reasonable for a child to be examined by a person trained in that task with a video confrontation or in person. In Finland, in the northern Ostrobothnia region, distances to hospital controls can be rather long, as already mentioned in the introduction. However, the private sector operates very widely in smaller cities or is located closer to the patient than the hospital. The private sector optometrists, who do visual acuity controls daily, could thus cooperate with the hospital district with service vouchers through social and health care reform. The reception and examinations of the optometrist take place in a room that is standardized, and the research methods are validated. Optometrists have high skills especially in visual acuity testing and thus, could perform the testing reliably also when the conditions are challenging, for example due to the vivid nature or lack of concentration of the small children. At that time, the investigator's authority may facilitate the examination of the child compared to a situation where the guardian would control the child. If the optometrist services are not available, there is a health nurse's office in every municipality, to whom visual acuity examination is also familiar, although the expertise is not as broad as the optometrists have.

4.4.4 Conclusion

From the available applications, the Peek Acuity was considered as the best option for the mobile visual acuity testing. However, it also included limitations that question its usability and reliability in the Finnish context. In conclusion, no perfectly suitable application was found, that was available in both iOS and Android based phones, in Finnish, without a subject to charge and which could be put into practice shortly and ensure standardized situations that would be comparable now and in the future. Also, the variables in home testing environment without an engaging professional set a high risk on the reliability. Applications or programs with a charge that would be considered to the Northern Ostrobothnia hospital district are needed to make a broader assessment. However, at this point, it would be possible to consider testing the visual acuity remotely through video confrontation pursued by the hospital's nurse or optometrist with a printed chart. With this option, changing the paper chart frequently could be justified to prevent a child from memorizing the letters. Another option could be that local optometrists in the private sector or public health nurses in child health clinics or health centres performing the intermediate control for amblyopic patients. Then, guardians record information on the new digital care pathway.

When considering future directions, if a promising application is to be found, it could be tested with a study group of 50 to 100 amblyopic children, for example. The functionality and reliability of the application could be tested in three different surroundings; the child's visual acuity could be examined first with the application at the home by the parent, then with a video confrontation led by the hospital nurse or optometrist and, the latest, at the clinic with a standardised visual acuity chart. After this, the results would be compared. It would also be good to collect data about user experiences from parents and clinicians.

4.5 Specific Aim 4

The fourth specific aim was to develop a digital care pathway for amblyopic patients.

4.5.1 Methods

Aim was pursued through the planning and content production stages of the Health Village digital care pathway development. The stages are presented in more details in the methodology chapter 3.5.

4.5.2 Results

Following the planning and content production stages and by answering to the objectives 1, 2, and 3, a suggestion for a structure to the digital care pathway for amblyopia was formed. The digital care pathway model is presented in figure 4. In more detail, a suggestion for the new digital care pathway includes the following steps: in step one, the guardian of the child with diagnosed amblyopia logs in to the digital care pathways, and in steps two and three, the guardian can get reliable information about amblyopia in one place. In step four, a contact channel holds contact information with a frequently asked questions section and the possibility of contacting the hospital personnel via messages. Lastly, in step five, control measurements can be added.

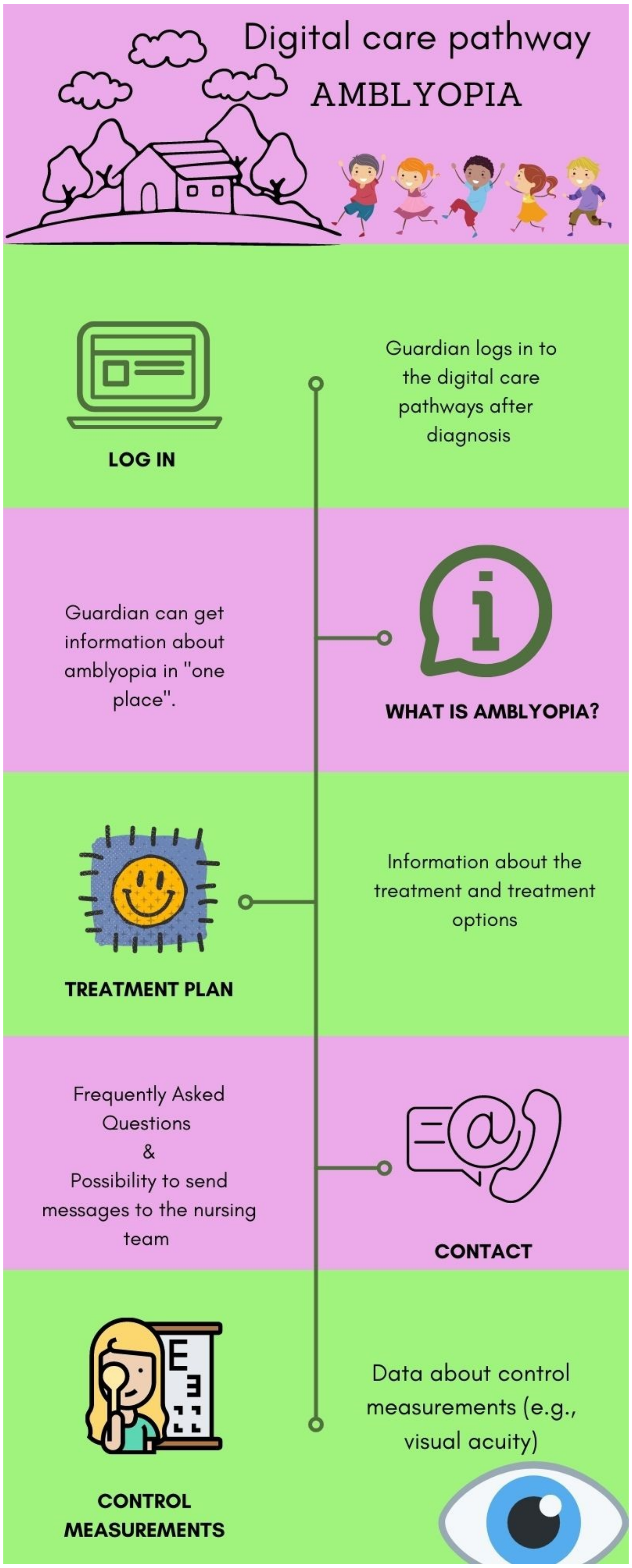

FIGURE 4. Amblyopia digital care pathway design

4.5.3 Discussion

Clear instructions and steps in the digital treatment pathway are necessary to find and access the reliably information of amblyopia easily. This was found when previous studies on the experience of using digital care pathways were reviewed (Keveri, 2022; Merioksa, 2020). Therefore, the amblyopia digital care pathway paid particular attention to the clarity of the structure and instructions, and to ensuring that information about amblyopia was at a level that the user could understand.

This development project's strength is that it is based on the latest research. The development of the pathway also takes into account the experiences of professionals working in the field, i.e. the development work has been done at the interface between research and practice. A limitation of the project is that the needs of amblyopia patients were not systematically identified, for example through a survey. It is therefore important that the care pathway is pre-tested and possibly further developed on the basis of feedback before it is implemented more widely. The functionality of the digital care pathway is tested during its implementation phase, e.g., by user experience surveys. Surveys enable the evaluation of which areas still require elaboration and editing.

4.5.4 Conclusion

This digital care pathway provides an example of how digital services can be developed and implemented as a part of the current care pathways. The amblyopia digital care pathway showcases how the already existing phases of the care pathways could be evaluated for their potential to be implemented in a digital form. This is especially important in the current health care situation in Finland, where the public services are struggling to answer to the needs and will be even more in the future due to the aging population. Telemedicine and digital care pathways could be a part of the new, cost-effective solutions.

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