Economic evaluation of an at-home blood sampling method focusing on patients with juvenile idiopathic arthritis (JIA)

Report

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Abstract

Background. For patients with chronic conditions, it is often necessary to have their health status and possible side effects of medication monitored with three-monthly phlebotomy in the hospital. This study provides insights in the cost impact of five different alternatives to phlebotomy in the Wilhelmina Children's Hospital (WCH) in patients with juvenile idiopathic arthritis (JIA), including an at-home finger-prick or point-of-care (POC) test, a phlebotomist visiting the patient at home, and the patient visiting a service phlebotomy centre or a regional hospital.

Methods. The cost impact of these alternative blood sampling strategies, compared to current practice, was determined using a one-year time horizon and from a hospital perspective as well as from a societal perspective. First, the total costs for each blood sampling scenarios were calculated by adding up the associated resource use and accompanying costs for each scenario. Second, realistic one-year scenarios were outlined in which the cost impact is shown when one or two phlebotomies in the WCH would be replaced with one of the alternative scenarios. Third, the same one-year scenarios were outlined in which the costs of consultations were included. Finally, a one-way sensitivity analysis and a probabilistic sensitivity analysis were performed on these one-year scenarios.

Results. Blood sampling in the WCH costs €123.98 from a societal perspective, while an at-home finger-prick or an at-home POC test costs €33.98 and €22.40, respectively. A phlebotomist visiting the patient at home costs €52.19 and the patient visiting a service phlebotomy centre or a regional hospital costs €46.18 and €49.67, respectively. Over one year, the societal costs of blood sampling in the WCH are €495.67/patient. When replacing one or two phlebotomies in the WCH with an at-home finger-prick, the annual costs will decrease to €405.96 and €305.35 respectively, and in case of one or two replacements with a POC test, the annual costs decrease to €394.37 and €282.18 respectively. When one or two phlebotomies are replaced with a phlebotomist visiting the patient at home, the annual costs decrease to €424.13 and €352.28 respectively, while one or two replacements with a visit to a service phlebotomy centre lead to decreased annual costs of €418.10 and €340.22 respectively. Finally, one or two replacements with a visit to a regional hospital lead to decreased costs of €421.54 and €347.11 respectively.

Conclusion. Replacing one or two phlebotomies in the WCH with the patient performing an at-home finger prick or an at-home POC test were found to be the most cost saving alternatives. Therefore these scenarios can be considered a good alternative for in-hospital phlebotomy. However, these alternatives must be completely safe for the patient and also the wishes of the patient and their parents/caregivers should be taken into account when choosing an alternative.

Background

For patients with chronic conditions, it is often necessary to have their health status and possible side effects of medication monitored [1]. This is done by routine venous blood sampling (phlebotomy) in the hospital. These routine visits to the hospital can put a significant burden on the personal life of the patient and their family and they also bring substantial costs to the healthcare system and to society [2]. In general, phlebotomy in the hospital can be considered a time-consuming and costly procedure due to personnel requirements from the hospital's perspective and logistical requirements from the perspective of the patient and potentially also for parents/caregivers, such as labour productivity losses and travel time [3].

One convenient alternative might be at-home blood sampling, in which blood is obtained through capillary blood sampling. Capillary blood sampling is a technique in which blood will be collected via a puncture in the finger or heel [4]. Compared to venous blood sampling, capillary blood sampling is a relatively easy method, requires small volumes of blood and is less invasive, which enables patients or their parents to perform capillary blood sampling at home, when they are given the right instructions [5–7].

Patients with chronic conditions often visit the hospital every three months for routine blood sampling, which is mostly combined with a consultation with their nurse and/or physician. At-home blood sampling allows patients to self-collect at their convenience instead of having to adapt their schedule for a phlebotomy appointment at the outpatient department in the hospital or a service phlebotomy centre. This decreases patient burden while simultaneously reducing travel time and labour productivity losses [8,9]. At-home blood sampling may enable physicians to remotely monitor a patients' health status and thereby reducing the number of check-ups at the hospital [10].

When patients have an appointment with their treating physician to discuss their laboratory test results, they can either self-collect a blood sample at home or have a blood sample taken at a phlebotomy location close to home, a few days before the actual appointment. This ensures that blood test results are available for the physician during the routine check-up appointment, which is currently not the case, since the consultation mostly follows directly after the blood withdrawal. When the blood sampling is done in advance, the treating physician can immediately include these laboratory results in the treatment plan for the patient, which makes the consultations more useful [9].

In addition to at-home sampling through a finger-prick and sampling in the treating hospital prior to a consultation, there are different options available for blood sampling, which involves alternative locations of blood withdrawal, or the use of a point-of-care (POC) device. More specifically, a venous blood sample can be taken at different locations, such as an academic hospital, a regional hospital, a service phlebotomy centre or at-home by a phlebotomist visiting the patient. Additionally, besides self-sampling through a finger-prick and sending the blood sample to the laboratory, this capillary blood sample could also be tested on a point-of-care (POC) device.

For the current study, it is assumed that the chosen blood sampling method does not impact the test results and therefore does not affect health outcomes. This is in line with findings from recent studies who have shown a good concordance between venous blood sampling and capillary blood sampling for various biochemical analytes [11,12]. Also, another aspect that is crucial for the potential implementation of at-home blood sampling, is the convenience of this blood sampling method, which is currently being investigated. In addition, before a well-considered decision can be made regarding the implementation of at-home blood sampling, the health economic impact must be determined, which is the goal of the current study. This includes an analysis of the impact on reducing labour productivity losses and travel costs, in order to capture the full economic impact of remote blood sampling as compared with phlebotomy in the hospital.

Although remote capillary blood self-sampling via a finger-prick could potentially benefit many patients with chronic conditions, the current study will focus on patients with juvenile idiopathic arthritis (JIA). JIA is the most common chronic rheumatic disease in childhood, which is of unknown etiology. For the diagnosis of JIA, required criteria are a disease onset prior to the age of 16 years and arthritis persisting for longer than 6 weeks [13]. JIA patients are often treated with the disease-modifying anti-rheumatic drug methotrexate (MTX). Use of this drug requires three-monthly check-ups of several analytes in the blood [14]. One of the analytes to be investigated for monitoring MTX is the liver enzyme alanine aminotransferase (ALT), which will be the focus of this study.
When patients have to visit the hospital for these check-ups, it causes them to regularly miss schooldays and their parents/caregivers to be absent from work. Besides, the results of these laboratory tests are not immediately available after the phlebotomy. As a result of this, the results mostly cannot be used for treatment decisions during the consultation with the pediatric rheumatologist on that same day, making additional appointments or phone calls necessary and the current way of blood sampling insufficient. In addition, it is suggested that some patients are potentially able to skip one or two of their yearly visits to their treating pediatric rheumatologist, although the three-monthly ALT checkups should take place. For the majority of these patients, it will be more convenient not having to go to the hospital in which they are treated for their JIA only to undergo a blood withdrawal.

In an ongoing study in the Wilhelmina Children's Hospital (WCH), which is part of the University Medical Centre Utrecht (UMCU), it is currently investigated whether children with JIA and their parents/caregivers are able to conduct a finger-prick at home and what the expected impact of this would be on patients' and parents' satisfaction. The insights gathered in the current study will facilitate the UMCU, as well as other hospitals and healthcare providers in the Netherlands and abroad, to make a well-informed decision regarding the implementation of remote capillary blood sampling in daily practice, as well as the most cost-efficient set-up of such an approach. This study will therefore investigate the following research question: *What is the impact of implementing an at-home finger-prick self-sampling method, compared to in-hospital phlebotomy, to replace one or two of the three-monthly check-ups per year, among patients with juvenile idiopathic arthritis (JIA) who use MTX, on costs from a societal perspective?*

In addition, the following sub-question has been defined:
What other blood sampling scenarios besides an at-home finger-prick self-sampling method are potentially suitable to replace regular three-monthly check-ups in the hospital and what is their cost impact?

Methods

In this study, the cost impact of an at-home finger-prick self-sampling method compared to in-hospital phlebotomy in JIA patients was determined from a hospital perspective and a societal perspective.

Study target group

The target group in this study were patients with JIA treated in the WCH (Utrecht, the Netherlands). This concerns patients who are being treated with MTX and whose health status and treatment is monitored with three-monthly blood testing.

Resource use and accompanying costs

The cost impact of different scenarios of blood sampling was determined both from a hospital perspective and from a societal perspective, which is the recommended perspective according to the Dutch Costing Manual [15]. Therefore, all hospital-related costs of the different blood sampling scenarios were included, such as costs for blood withdrawal, transportation, and costs for analysing blood samples. Additionally, expenditures of patients and parents/caregivers, such as travel costs, parking costs and costs for labour productivity losses were included.

For the analysis, a one-year time horizon was considered in which it was assumed that, in current practice, four blood sampling moments would take place within the treating hospital (WCH). It was assumed that either one or two of these four blood sampling moments can be replaced with one of the alternative scenarios below (Table 1). In case of an elevated ALT test, the patient is called by the rheumatologist to discuss the abnormal results and the blood test will be repeated in a few weeks.

Table 1: Different scenarios of blood sampling for JIA patients.

Scenario	Description
Current scenario	Phlebotomy in the treating hospital (including analysis)
Scenario 1	Patient performs an at-home finger-prick and sends the collected blood sample to the laboratory for analysis
Scenario 2	Phlebotomist visits a patient at home to perform blood sampling and takes it to the laboratory for analysis
Scenario 3	Patient visits a service phlebotomy centre and the sample is send to a regional laboratory or regional hospital for analysis
Scenario 4	Patients visits a regional hospital for blood sampling (including analysis)
Scenario 5	Patient performs an at-home point-of-care test

In each scenario, the blood sampling involves the liver enzyme alanine aminotransferase (ALT).

Hospital-associated resource use and accompanying costs

Costs for blood withdrawal and laboratory testing were calculated by taking the average of the reimbursement tariffs of five Dutch hospitals. These reimbursement tariffs are shown in Appendix A, Table 1 [16–20]. In case of an elevated ALT test (which was defined as >1.5x upper limit of normal), costs for a telephone consultation were added (regardless of the scenario), since the paediatric rheumatologist calls a patient to discuss the abnormal result. Telephone consultations were valued as 25% of the costs of a paediatric department visit (€123.38) as reported in the Dutch Costing Manual, which equals €30.85 per telephone consultation [15]. Additionally, when ALT was elevated, costs for an extra ALT test were added, since it is assumed that the analysis would be repeated within a few weeks. It was assumed that the extra test in the current scenario would take place at a service phlebotomy centre or a regional hospital, unless the WCH is closer. In the scenarios 1-5, the method of the second ALT test was the same as the first ALT test. Data on the number of elevated ALT tests

was obtained from the WCH. The proportion of elevated ALT test of all performed ALT tests amounted to 4.1% (315 out of 7,765 ALT tests between 3 January 2005 and 7 March 2023).
Costs of shipment of blood samples by mail were included when applicable. Shipment by courier was already included in the tariffs of the Dutch Healthcare Authority.
In scenarios 1 and 5, instruction costs for blood sampling are included, since the blood sampling in those scenarios takes place at-home without supervision of a medical specialist. The instructions were assumed to last 15 minutes and were assumed to be given by a nurse. Costs for this instructions are valued as 25% of the costs for labour productivity losses per hour, which equals €10.61 [15].

Travel, parking and labour productivity loss and accompanying costs

Travel time and distance, parking time and the amount of labour productivity loss were determined for each scenario. First, in the current scenario, the travel time and distance to the WCH have been estimated on data from 80 patients from earlier research with JIA patients, of which the average has been taken [21]. For the travel distance in scenarios 1-5, standard calculation values from the Dutch Costing Manual were used. Travel costs per kilometre (€0.30) were obtained via the Dutch Healthcare Authority [22]. In the current scenario, 50% of the travel costs and costs for labour productivity loss have been calculated, because these costs cannot fully be attributed to the blood collection. The other part can be attributed to a consultation, since a blood sampling moment in the WCH is only plausible when the patient is already there for a consultation.
Second, the lost labour productivity for parents/caregivers was determined by adding up travel time (if applicable) and the estimated time spent with the blood sampling for each scenario, while assuming that one parent/caregiver would join the patient to the phlebotomy and paediatric rheumatologist consultation. Costs for labour productivity losses were obtained from the Dutch Costing Manual, which were €42.45 per hour [15]. Third, parking time was equated to the time spent in the hospital. Parking costs per hour (€1.80) were obtained from the website of the WCH [23].
For telephone consultations, labour productivity loss was assumed to be 10 minutes per telephone consultation. The values of the travel distances and travel times used in each scenario can be found in Appendix A, Table 2.

All costs were converted to 2022 Euros by using the Dutch consumer price indices (CPI), provided by Statistics Netherlands [24].

Analyses

The analyses in this study were performed in Microsoft Excel. The total costs for each blood sampling scenario in Table 1 were calculated by adding up the associated cost aspects for each scenario. Then, one-year scenarios were defined in which the cost impact is shown assuming that either one or two blood sampling moments in the WCH (current practice) would be replaced by one of the five alternative scenarios from Table 1. Additionally, one-year scenarios were defined, in which the costs of consultations were included. It has been decided to also show the one-year scenarios with the consultations included, since a blood sampling moment is often combined with a consultation with the treating physician and therefore it provides a complete overview of the annual costs.

A one-way sensitivity analysis (SA) was performed to determine the impact of uncertainty of individual parameters on the cost difference between current practice and one or two replacements with one of the five alternative scenarios. In this deterministic sensitivity analysis, one cost parameter was varied at the time by the lower or upper limit of the 95% confidence interval (CI), while all other input parameters were kept constant. For both changes, the impact on the cost difference of each scenario was assessed. The results of this one-way sensitivity analysis were visualized in tornado diagrams.

Additionally, a probabilistic sensitivity analysis (PSA) was performed in which all deterministic values of the input parameters were simultaneously replaced with probabilistic values. The PSA in this study consisted of 10,000 runs. Outcomes of the PSA were presented as the averages of the one-year scenarios and their incremental costs compared to current practice, including their 95% CI.
All input parameters were represented by a distribution to acquire probabilistic values and 95% CIs. A gamma distribution was used for cost and time parameters, and a beta distribution for probability parameters. The 95% CI for the costs of blood withdrawal at the hospital, service phlebotomy centre or a phlebotomist visit at home could be calculated from the standard error (SE) resulting from the standard deviation, since multiple values were known about this. For the remaining parameters, the 95% CI was based on an assumed SE of 25%. An overview of all (deterministic) cost parameters is provided in Appendix B.

Results

In this study, the results are divided in different parts. First, the costs per blood sampling method are shown. Second, the results of the one-way SA are shown. Third, the costs of the one-year scenarios are shown in which either one or two blood sampling moments in the WCH are replaced with one of the five alternative scenarios. These costs are shown from the hospital perspective and the societal perspective, whereby consultations were not taken into account. In this way, the cost impact of the different blood sampling methods emerges more clearly. Last, the same one-year scenarios are shown in which costs of consultations were also taken into account. It has been decided to also show the one-year scenarios including the consultations, since a blood sampling moment is often combined with a consultation with the treating physician and therefore provides a complete overview of the annual costs. The costs of both one-year scenarios (step 3 and step 4) are based on the results of the PSA. Visualization of the structure of the results is shown in Figure 1.

Figure 1. *Visualization of the structure of the results*

Costs per blood sampling method

For the costs in this paragraph, the costs per blood sampling method have been considered. Viewed from the hospital perspective, the total costs are higher in the alternative blood sampling scenarios compared to the current scenario, which means that blood sampling in the WCH in itself has the lowest costs. The costs of scenarios 1 (at-home finger-prick) and scenario 5 (at-home POC test) are mainly higher because of the instruction costs included in these scenarios. The costs of the current scenario (blood sampling in the WCH) and scenario 4 (blood withdrawal in a regional hospital) are almost the same, because both involve a blood sampling moment in the hospital.

When the costs of lost labour productivity and travel costs are also included (societal perspective), the total costs of the current scenario amount to €123.98. The costs of scenario 1 and scenario 5 are €33.98 and €22.40 respectively and are therefore lower than the current scenario. Therefore, scenario 1 and scenario 5 would decrease the costs of blood sampling with €90.01 (-72.6%) for scenario 1 and with

€101.58 (-81.9%) for scenario 5, respectively. In these scenarios there are hardly any labour productivity losses and travel expenses, as the blood withdrawal takes place at-home.

The societal costs of scenario 2 (blood withdrawal by a phlebotomist visiting the patient), scenario 3 (blood withdrawal at a service phlebotomy centre) and scenario 4 are €52.19, €46.18 and €49.67 respectively and are therefore also lower than the current scenario. Therefore, scenario 2, scenario 3 and scenario 4 would decrease the costs of blood sampling with €71.79 (-57.9%) for scenario 2, with €77.80 (-62.8%) for scenario 3 and with €74.32 (-59.9%) for scenario 4, respectively. These scenarios are lower due to the lower costs of lost labour productivity and travel expenses, because these three scenarios take place closer to home, or at the patient's home. Nevertheless, the cost decrease in scenarios 2-4 is lower compared to scenarios 1 and 5, because travel costs and costs for lost labour productivity are comparatively lower in scenarios 1 and 5.

In Figure 2 and Table 2, the structure of the total costs per blood sampling method is shown.

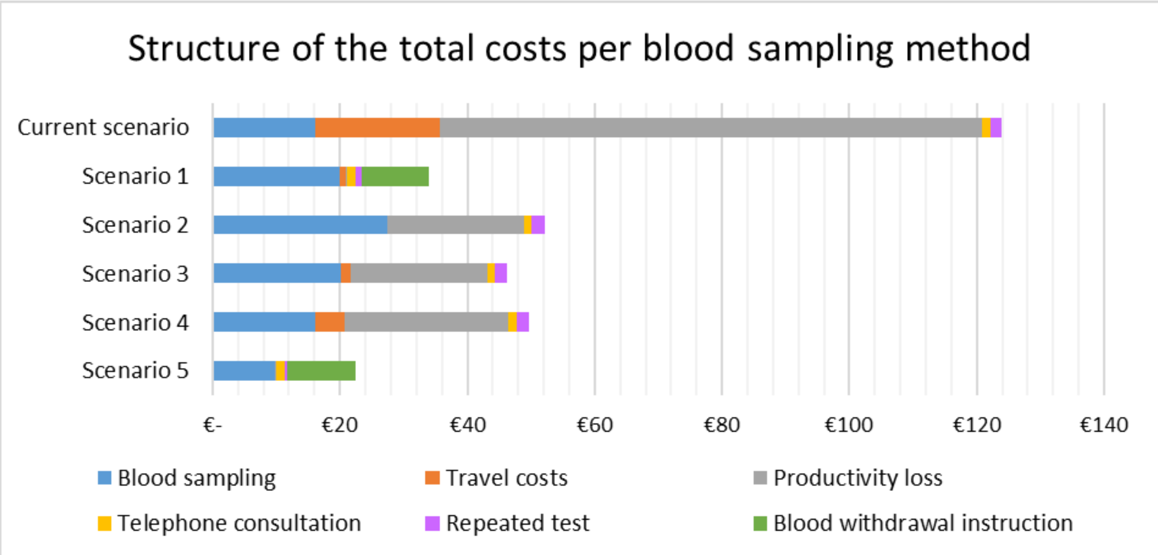

Figure 2. *Structure of the total costs per blood sampling method*

Table 2. Overview of the total costs per blood sampling method

Scenarios*	Costs for blood sampling[1]	Costs for telephone consultation	Costs for a repeated test	Costs for blood withdrawal instruction	Total costs hospital perspective[2]	Travel costs	Costs for labour productivity losses	Total costs societal perspective[2]
Current scenario	€ 16.07	€ 1.25	€ 1.87	-	**€ 19.19**	€ 19.60	€ 85.19	**€ 123.98**
Scenario 1	€ 20.02	€ 1.25	€ 0.91	€ 10.61	**€ 32.79** (+€ 13.60)	€ 0.90	€ 0.29	**€ 33.98** (-€ 90.01)
Scenario 2	€ 27.39	€ 1.25	€ 2.03	-	**€ 30.68** (+€ 11.49)	-	€ 21.51	**€ 52.19** (-€ 71.79)
Scenario 3	€ 20.12	€ 1.25	€ 1.80	-	**€ 23.17** (+€3.98)	€ 1.50	€ 21.51	**€ 46.18** (-€ 77.80)
Scenario 4	€ 16.07	€ 1.25	€ 1.94	-	**€ 19.26** (+€ 0.07)	€ 4.65	€ 25.76	**€ 49.67** (-€ 74.32)
Scenario 5	€ 9.79	€ 1.25	€ 0.19	€ 10.61	**€ 22.12** (+€ 2.93)	-	€ 0.29	**€ 22.40** (-€ 101.58)

[1] Including costs for ALT analysis.

[2] Incremental costs compared to the current scenario between brackets.

* Current scenario = phlebotomy in the WCH / Scenario 1 = at-home finger-prick / Scenario 2 = phlebotomist visit at-home / Scenario 3 = visiting a service phlebotomy centre / Scenario 4 = Visiting a regional hospital / Scenario 5 = at-home POC test.

Results one-way SA

In Appendix C, Figures 1A-E and 2A-E, the six parameters with the largest impact on the cost outcome due to parameter uncertainty are shown for every one-year scenario (with one or two replacements of a blood sampling moment in the WCH) compared to current practice. The one-way SA shows that, when one phlebotomy in the WCH will be replaced with the alternative scenarios, the costs for labour productivity losses per hour have the highest impact in all five scenarios, followed by the travel time to the WCH and the time remaining in the WCH.

When two phlebotomies in the WCH will be replaced with the alternative scenarios, costs for labour productivity losses per hour remain the parameter with the highest impact in all five scenarios, also followed by the travel time to the WCH and the time remaining in the WCH.

One-year scenarios based on PSA results

Excluding the costs of consultations

In current practice, it is assumed that the patient visits the WCH four times per year for blood sampling, without having a consultation. Viewed from a hospital perspective, the total annual costs are higher in all alternative scenarios compared to current practice. Only when two blood sampling moments in the WCH will be replaced with scenario 5, the annual costs are lower. This means that a blood sampling moment in the WKZ on an annual basis is in itself a method of blood collection that entails less costs compared to the other scenarios.

When the costs of lost labour productivity and travel costs are also included (societal perspective), the annual costs in current practice increase to €495.97/patient. When one blood sampling moment in the WCH will be replaced with scenario 1 or 5, the annual costs will decrease to €405.96 and €394.37 respectively, representing costs reductions of €90.01 (-18.1%) and €101.60 (-20.5%), for scenario 1 and 5 respectively. When one blood sampling moment in the WCH will be replaced with scenario 2, scenario 3 or scenario 4, the annual costs will decrease to €424.13, €418.10 and €421.54 respectively, representing cost reductions of €71.84 (-14.5%), €77.87 (-15.7%) and €74.43 (-15.0%), for scenario 2, 3 and 4 respectively. However, these cost reductions are lower compared to the cost reductions in scenario 1 and 5, mainly due to the difference in costs of labour productivity losses.

When two blood sampling moments in the WCH will be replaced with scenario 1 or 5, the annual costs will decrease to €305.35 and €282.18 respectively, representing cost reductions of €190.62 (-38.4%) and €213.79 (-43.1%), for scenario 1 and scenario 5 respectively. When two blood sampling moments in the WCH will be replaced with scenario 2, scenario 3 or scenario 4, the annual costs will decrease to €352.28, €340.22 and €347.11 respectively, representing cost reductions of €143.69 (-29.0%), €155.75 (-31.4%) and €148.86 (-30.0%), for scenario 2, 3 and 4 respectively. These cost reductions are also lower compared to the cost reductions in scenario 1 and 5, also mainly due to the difference in costs of labour productivity losses.

The one-year cost impact when replacing one or two blood sampling moments in the WCH with scenario 1-5 is shown in Figure 3 and Table 3.

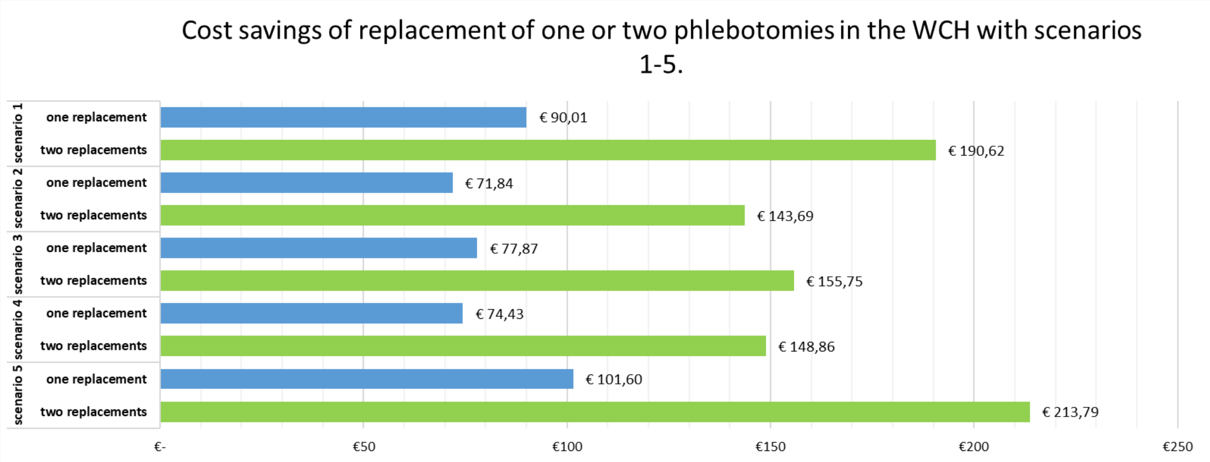

Figure 3. *One-year cost savings when replacing one or two phlebotomies in the WCH*

Table 3. Total annual costs of replacement of 1 or 2 phlebotomies in the WCH with scenario 1-5

Scenarios	Costs for blood sampling[1]	Costs elevated ALT[2]	Costs for blood withdrawal instruction	Total costs hospital perspective[3]	Travel costs	Costs for labour productivity losses	Total costs societal perspective[3]
Current practice	€ 64.30	€ 12.56	-	**€ 76.86**	€ 78.62	€ 340.50	**€ 495.97**
One replacement with scenario 1	€ 68.24	€ 11.60	€ 10.60	**€ 90.44** (+€ 13.58)	€ 59.86	€ 255.66	**€ 405.96** (-€ 90.01)
Two replacements with scenario 1	€ 72.18	€ 10.64	€ 10.60	**€ 93.42** (+€ 16.56)	€ 41.11	€ 170.82	**€ 305.35** (-€ 190.62)
One replacement with scenario 2	€ 75.62	€ 12.72	-	**€ 88.34** (+€ 11.49)	€ 58.96	€ 276.82	**€ 424.13** (-€ 71.84)
Two replacements with scenario 2	€ 86.94	€ 12.89	-	**€ 99.83** (+€ 22.97)	€ 39.31	€ 213.15	**€ 352.28** (-€ 143.69)
One replacement with scenario 3	€ 68.35	€ 12.49	-	**€ 80.84** (+€ 3.98)	€ 60.46	€ 276.79	**€ 418.10** (-€ 77.87)
Two replacements with scenario 3	€ 72.40	€ 12.42	-	**€ 84.82** (+€ 7.96)	€ 42.31	€ 213.09	**€ 340.22** (-€ 155.75)
One replacement with scenario 4	€ 64.30	€ 12.62	-	**€ 76.93** (+€ 0.07)	€ 63.61	€ 281.01	**€ 421.54** (-€ 74.43)
Two replacements with scenario 4	€ 64.30	€ 12.69	-	**€ 76.99** (+€ 0.13)	€ 48.60	€ 221.52	**€ 347.11** (-€ 148.86)
One replacement with scenario 5	€ 58.01	€ 11.14	€ 10.60	**€ 79.75** (+€ 2.89)	€ 58.96	€ 255.66	**€ 394.37** (-€ 101.60)
Two replacements with scenario 5	€ 51.72	€ 9.73	€ 10.60	**€ 72.05** (-€ 4.81)	€ 39.31	€ 170.82	**€ 282.18** (-€ 213.79)

[1] Including costs for ALT analysis.
[2] Consists of the costs for a telephone call with the rheumatologist and the costs for a repeated test.
[3] Incremental costs compared to current practice between brackets.

In Figure 4, 95% confidence ellipses are shown, where the costs of the current practice are plotted against the costs of replacing one or two blood sampling moments in the WCH with scenario 1 to 5.

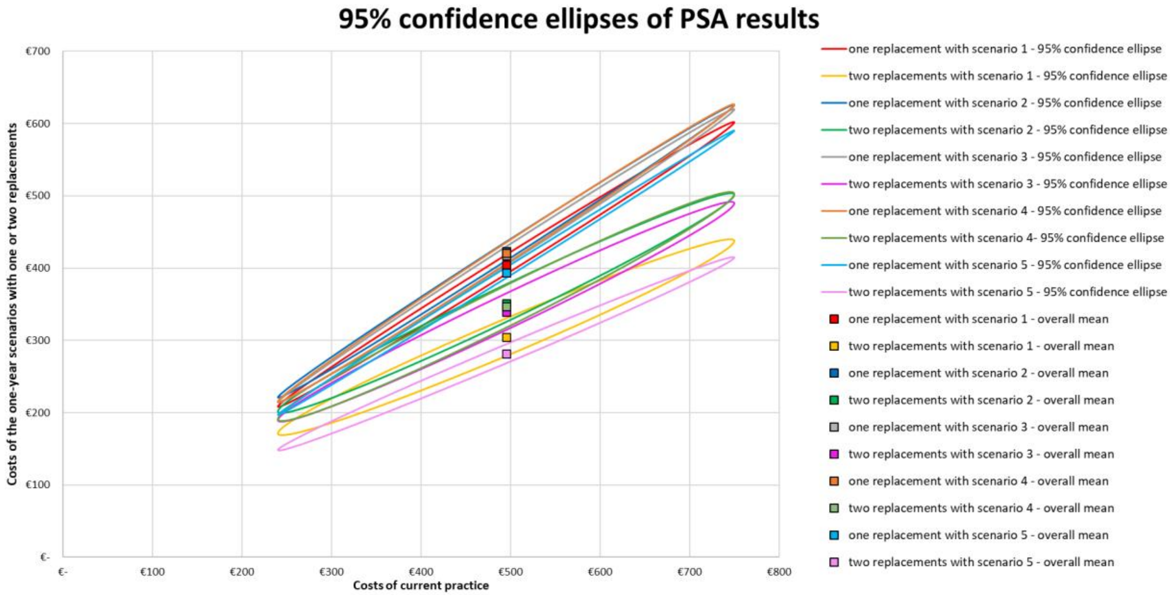

Figure 4. *95% confidence ellipses on the results of the PSA of 10,000 iterations*

Including the costs of consultations

In the paragraph below, the costs for consultations are included. It was assumed that, in current practice, four blood sampling moments would take place in the hospital (WCH) and which would be combined with an appointment with the paediatric rheumatologist. This section assumes that the idea exists that the number of consultations can be reduced among patients with stabile conditions. For that reason, in this section the cost impact is examined when either one or two blood sampling moments plus consultations in the WCH are replaced with one of the five alternative scenarios.

Viewed from a hospital perspective, the total annual costs are lower in all alternative scenarios compared to current practice. This is because consultation costs are included in current practice, while in each alternative scenario they expire one or two times.

When the costs of lost labour productivity and travel costs are also included (societal perspective), the annual costs in current practice will increase to €1,407.04/patient.
When one blood sampling moment plus consultation in the WCH will be replaced with scenario 1 or 5, the annual costs will decrease to €1,089.28 and €1,077.71 respectively, representing costs reductions of €317.77 (-22.6%) and €329.34 (-23.4%), for scenario 1 and 5 respectively. When one blood sampling moment plus consultation in the WCH will be replaced with scenario 2, scenario 3 or scenario 4, the annual costs will decrease to €1,107.40, €1,101.46 and €1,104.97 respectively, representing cost reductions of €299.64 (-21.3%), €305.58 (-21.7%) and €302.08 (-21.5%), for scenario 2, 3 and 4 respectively. These cost reductions are a bit lower compared to the cost reductions in scenario 1 and 5, mainly due to the difference in costs of labour productivity losses. However, the differences between the scenarios are small.

When two blood sampling moments plus consultations in the WCH will be replaced with scenario 1 or 5, the annual costs will decrease to €760.91 and €737.76 respectively, representing cost reductions of €646.14 (-45.9%) and €669.28 (-47.6%), for scenario 1 and scenario 5 respectively. When two blood sampling moments plus consultations in the WCH will be replaced with scenario 2, scenario 3 or scenario 4, the annual costs will decrease to €807.76, €795.88 and €802.89 respectively, representing cost reductions of €599.28 (-42.6%), €611.17 (-43.4%) and €604.16 (-42.9%), for scenario 2, 3 and 4 respectively. These cost reductions are also lower compared to the cost reductions in scenario 1 and 5, also mainly due to the difference in costs of labour productivity losses. However, the differences between the scenarios are small here as well.

The one-year cost impact when replacing one or two blood sampling moments plus consultations in the WCH with scenario 1-5 is shown in Figure 5 and Table 4.

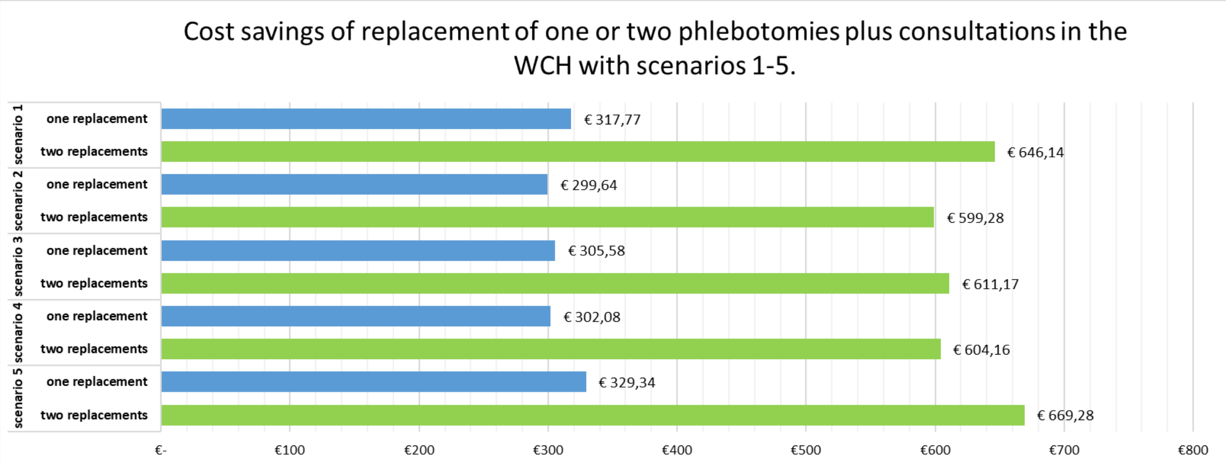

Figure 5. *One-year cost savings when replacing one or two phlebotomies plus consultation in the WCH*

Table 4. Total annual costs of replacement of 1 or 2 phlebotomies plus consultation in the WCH with scenario 1-5

Scenarios	Costs for blood sampling[1]	Costs elevated ALT[2]	Instruction costs	Consultation costs	Total costs hospital perspective[3]	Travel costs	Costs for labour productivity losses	Total costs societal perspective[3]
Current practice	€ 64.28	€ 12.48	-	€ 495.04	**€ 571.80**	€ 156.83	€ 678.41	**€ 1.407.04**
One replacement with scenario 1	€ 68.25	€ 11.52	€ 10.61	€ 371.28	**€ 461.67** (-€ 110.14)	€ 118.52	€ 509.09	**€ 1,089.28** (-€ 317.77)
Two replacements with scenario 1	€ 72.23	€ 10.57	€ 10.61	€ 247.52	**€ 340.92** (-€ 230.88)	€ 80.20	€ 339.78	**€ 760.91** (-€ 646.14)
One replacement with scenario 2	€ 75.61	€ 12.65	-	€ 371.28	**€ 459.54** (-€ 112.27)	€ 117.62	€ 530.24	**€ 1,107.40** (-€ 299.64)
Two replacements with scenario 2	€ 86.94	€ 12.81	-	€ 247.52	**€ 347.27** (-€ 224.54)	€ 78.41	€ 382.08	**€ 807.76** (-€ 599.28)
One replacement with scenario 3	€ 68.33	€ 12.41	-	€ 371.28	**€ 452.03** (-€ 119.78)	€ 119.12	€ 530.31	**€1,101.46** (-€ 305.58)
Two replacements with scenario 3	€ 72.38	€ 12.35	-	€ 247.52	**€ 332.25** (-€ 239.56)	€ 81.42	€ 382.21	**€ 795.88** (-€ 611.17)
One replacement with scenario 4	€ 64.28	€ 12.55	-	€ 371.28	**€ 448.11** (-€ 123.69)	€ 122.46	€ 534.59	**€ 1,104.97** (-€ 302.08)
Two replacements with scenario 4	€ 64.28	€ 12.62	-	€ 247.52	**€ 324.42** (-€ 247.39)	€ 87.69	€ 390.78	**€ 802.89** (-€ 604.16)
One replacement with scenario 5	€ 58.03	€ 11.08	€ 10.61	€ 371.28	**€ 450.99** (-€ 120.81)	€ 117.62	€ 509.09	**€ 1,077.71** (-€ 329.34)
Two replacements with scenario 5	€ 51.78	€ 9.67	€ 10.61	€ 247.52	**€ 319.57** (-€ 252.23)	€ 78.41	€ 339.78	**€ 737.76** (-€ 669.28)

[1] Including costs for ALT analysis.

[2] Consists of the costs for a telephone call with the rheumatologist and the costs for a repeated test.

[3] Incremental costs compared to current practice between brackets.

In Figure 5, 95% confidence ellipses are shown, where the costs of the current practice are plotted against the costs of replacing one or two blood sampling moments plus consultations in the WCH with scenario 1 to 5.

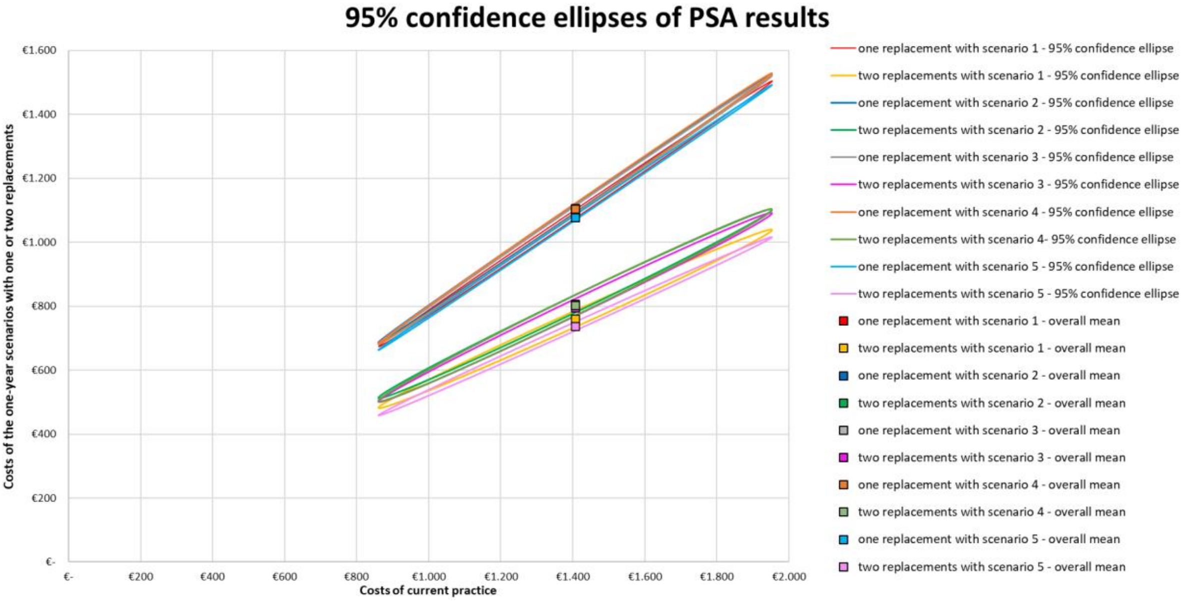

Figure 5. *95% confidence ellipses on the results of the PSA of 10,000 iterations*

Discussion

This study provides insights in the costs of five different blood sampling scenarios compared to phlebotomy in the WCH (current practice) and the annual cost impact of replacing one or two of these phlebotomies by one of the five different scenarios. If (without looking at the costs of consultations), seen in a year's time, one or two phlebotomies in the WCH will be replaced with the patient performing an at-home finger-prick (scenario 1) or an at-home POC test (scenario 5) the cost reductions are higher compared to replacing one or two phlebotomies with either a phlebotomist visiting the patient at-home for blood sampling (scenario 2), the patient visiting a service phlebotomy centre (scenario 3) or regional hospital (scenario 4) for blood sampling. When the costs of consultations are included, scenario 1 and 5 also show higher cost reductions compared to scenarios 2-4.

Telemonitoring

For the future, a possible addition to the five different blood sampling scenarios could be telemonitoring. The main purpose of telemonitoring is to replace regular specialist medical care and is being registered for the remote monitoring of a patient in the context of medical special treatment. In the Netherlands, telemonitoring can only since recently be registered and declared by medical specialists. The current tariff in the Netherlands is €168.06, which can be declared no more than once every 120 days [22]. Before telemonitoring can be fully used in practice, a well-developed system/application is required, as well as a CE quality mark, all of which require a financial investment. Therefore, the current tariff is presumably overestimated and is probably intended as an incentive to make medical specialists more enthusiastic about the use of telemonitoring. It is however questionable whether health insurers will eventually be prepared to (partially) reimburse these costs for telemonitoring.

Strengths and limitations

One of the strengths of this study is that five alternative scenarios for the standard phlebotomy have been considered. In addition, because two perspectives have been taken into account, it is immediately clear where the difference lies in just the costs of blood sampling from the hospital perspective and what the overall difference is from the societal perspective. In the end, all relevant costs were included, so that this study provides a good overall picture of the costs. Furthermore, the insights gathered in this study can support other hospitals and healthcare providers in the Netherlands and abroad to make a well-informed decision regarding the implementation of remote blood sampling in daily practice.

This study has several limitations. Firstly, assumptions had to be made for the time durations included in the different scenarios, which may have led to an underestimation of the times of labour productivity losses used in this study. This may in particular be the case for the scenario in which a phlebotomist visits the patient at-home for blood sampling (scenario 2). In this study, 30 minutes of labour productivity losses have been taken into account, although there is a good chance that in reality there are more labour productivity losses associated with this scenario because it is not exactly known at what time the phlebotomist will come by, so the parent/caregiver may have to take off some extra time off from work. It was difficult to estimate this and there was a lack of literature describing this. The same also applies to the scenarios of a blood withdrawal at a service phlebotomy centre or regional hospital. Therefore, the cost savings in these scenarios may have been overestimated. Suppose that the labour productivity losses in scenarios 2, 3 and 4 would have been one hour instead of 30 and 36 minutes, then the costs of labour productivity losses would increase from €21.51 and €25.76 to €42.74. Even then, the costs of these scenarios would then still be considerably lower than blood sampling in the WCH. Only when there is a total of more than 2.25 hours of lost labour productivity in these scenarios, the costs start to become higher compared to the current scenario. Although this is not completely realistic, because it is uncertain whether the labour productivity losses in the current scenario have been estimated correctly.
Secondly, the labour productivity losses could better be estimated if many more factors were taken into account, such as the number of hours that parents work, the type of job they have, what pay scale they are in, etc. In this study, the costs for labour productivity loss per hour were converted from 2014 to 2022, while the other data was obtained from 2022 sources. In the one-way SA, this was also the parameter with the largest impact on the cost outcome due to parameter uncertainty. If the costs for labour productivity losses were from a more recent year or calculated with more factors taken into account, the uncertainty on these parameters would probably have been lower.
Thirdly, important to mention for the ALT POC test (scenario 5) is that it has only recently been developed in Australia and first must be further developed and validated before this ALT POC test can actually be considered as an realistic alternative to phlebotomy in the WCH [25].
Fourthly, one of the pitfalls of taking blood samples at an external location (service phlebotomy centre or regional hospital) is that the results of the blood tests mostly do not end up in the patient's electronic health record, making it less convenient for the treating paediatric rheumatologist. More specifically, with regard to the trend monitoring of, in this case, the liver values, it would be best to always analyse a patient's blood tests at one central laboratory (in this case in the WCH), so that the results of the patient can be monitored over time.

Recommendations to the WCH

This study recommends the use of an at-home finger-prick (scenario 1) as the best alternative to blood sampling in the WCH (current scenario). Implementation of scenario 1 as alternative of the current scenario leads to a significant reduction in travel costs and labour productivity losses from a societal perspective. Also from the hospital perspective scenario 1 is the alternative with the second highest cost savings compared to the other scenarios. In addition, the at-home finger-prick has already been tested in practice, which simplifies implementation in daily practice.

The at-home finger-prick is preferred over the ALT POC test (scenario 5), since this POC test has not been fully developed yet and is therefore still not ready for use in daily practice.

Conclusion

In summary, the results of this study show that replacing one or two phlebotomies in the WCH with the patient performing an at-home finger-prick (scenario 1) or an at-home POC test (scenario 5) are the most cost saving alternatives from a societal perspective (regardless whether or not the costs of consultations are included). The majority of these cost savings is attributable to a reduction in productivity losses and travel costs. When one or two phlebotomies are replaced with a phlebotomist visiting the patient at-home (scenario 2), the patient visiting a service phlebotomy centre (scenario 3) or regional hospital (scenario 4) for blood sampling the cost reductions are lower compared to scenarios 1 and 5. These cost reductions mean that the scenarios can all be good alternatives to phlebotomy in the WCH. However, before choosing an alternative to blood sampling in the WCH, the wishes of the patient should also be taken into account. Lastly, since there was a lot of uncertainty about the labour productivity losses in this study, it would be good to conduct a more extensive analysis on this in a subsequent study.

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Appendix A – Resource use calculation values

Table 1. Reimbursement tariff of blood sampling in five Dutch hospitals

Declaration code	**UMC Utrecht** [16]	**Maasstad Hospital** [17]	**Medical Spectrum Twente** [18]	**RadboudUMC** [19]	**Jeroen Bosch Hospital** [20]	**Average**
074891	€ 2.19	€ 2.07	€ 1.65	€ 1.86	€ 2.09	€ 1.97
079986	€ 12.13	€ 11.45	€ 10.77	€ 10.68	€ 11.58	€ 11.32
079989	€ 7.03	€ 6.63	€ 6.02	€ 6.54	€ 6.70	€ 6.58
079990	€ 4.41	€ 4.16	€ 3.53	€ 3.93	€ 4.20	€ 4.05
079991	€ 13.49	€ 12.71	€ 14.05	€ 15.40	€ 14.85	€ 14.10

Definitions of the declaration codes of the Dutch Healthcare Authority [22]:

074891 Alanine aminotransferase (ALT), serum glutamic-pyruvic transaminase (SGPT), transaminase.

079986 Periodic home visits for clinical-chemical and/or microbiological laboratory tests, whereby the personal details of the patient are known to the healthcare provider at least 2 working days before the home visit.

079989 Order rate clinical-chemical and microbiological laboratory blood tests, excluding blood collection.

079990 Surcharge on order rate for decentralized collection of patient material.

079991 Order rate for clinical chemistry and microbiological laboratory tests, including blood sampling.

Table 2. Calculation values of the travel distances and travel times

Calculation value	**Value**
Travel distance Wilhelmina Children's Hospital	118.7 kilometres
Travel time Wilhelmina Children's Hospital	120 minutes
Travel distance regular hospital	14.0 kilometres
Travel time regional hospital	21 minutes
Travel distance service phlebotomy centre	5.0 kilometres
Travel time service phlebotomy centre	15 minutes
Travel distance mailbox	3.0 kilometres

Appendix B – Input parameters

Table 1. Input time and probability parameters

Parameters	**Category**	**Value**	**95% CI***	**Distribution**
Time blood sampling	Time blood sampling hospital	15	7.65 to 22.35	Gamma
	Time blood sampling ThuisLab	10	5.10 to 14.90	Gamma
	Time blood sampling home visit	10	5.10 to 14.90	Gamma
	Time blood sampling service phlebotomy centre	15	7.65 to 22.35	Gamma
	Time blood sampling point-of-care test	15	7.65 to 22.35	Gamma
	Additional time Wilhelmina Children's Hospital	45[1]	22.95 to 67.05	Gamma
	Additional time home visit	20	10.20 to 29.80	Gamma
Travel times	Travel time Wilhelmina Children's Hospital	120	61.20 to 178.80	Gamma
	Travel time ThuisLab	15	7.65 to 22.35	Gamma
	Travel time service phlebotomy centre	15	7.65 to 22.35	Gamma
	Travel time general hospital	21	10.71 to 31.29	Gamma
Time phone call	Time phone call	10	5.10 to 14.90	Gamma
Probability elevated ALT	Probability elevated ALT	0.0406	0.0207 to 0.0604	Bèta

CI = confidence interval, ALT = alanine aminotransferase.
All values are given in minutes.
* 95% CI is based on an assumed standard error of 25%.
[1] 50% of the real value.

Table 2. Input cost parameters

Parameters	Category	Cost	95% CI*	Distribution
Blood sampling costs	Hospital	€ 16.07	€15.18 to €16.96	Gamma
	Service phlebotomy centre	€ 20.12	€19.20 to €21.03	Gamma
	Home visit	€ 27.39	€26.52 to €28.26	Gamma
	ThuisLab	€ 20.02	€10.21 to €29.82	Gamma
	Point-of-care	€ 9.79	€4.99 to €14.59	Gamma
Travel costs[1]	Wilhelmina Children's Hospital	€ 39.20	€19.99 to €58.41	Gamma
	General hospital	€ 4.65	€2.37 to €6.93	Gamma
	Service phlebotomy centre	€ 1.50	€0.77 to €2.24	Gamma
	ThuisLab	€ 0.90	€0.46 to €1.34	Gamma
Labour productivity loss costs	Labour productivity loss costs per hour	€ 42.45	€21.65 to €63.25	Gamma
Outpatient visit costs	Paediatric department visit	€ 123.38	€62.93 to €183.84	Gamma
	Telephone consultation	€ 30.85	€15.73 to €45.96	Gamma
Instruction costs	Instruction costs per 15 minutes	€ 10.61	€5.41 to €15.81	Gamma

CI = confidence interval.
* 95% CI is based on an assumed standard error of 25%, except for the costs of blood sampling at the hospital, service phlebotomy centre or a home visit.
[1] Parking costs were included in the travel costs when traveling to the hospital, since almost all hospitals in the Netherlands have a paid parking lot. With ThuisLab, travel costs were seen as the costs associated with mailing the sample to the laboratory.

Appendix C – Results one-way sensitivity analysis

Results one-way sensitivity analysis with one replacement of the current scenario

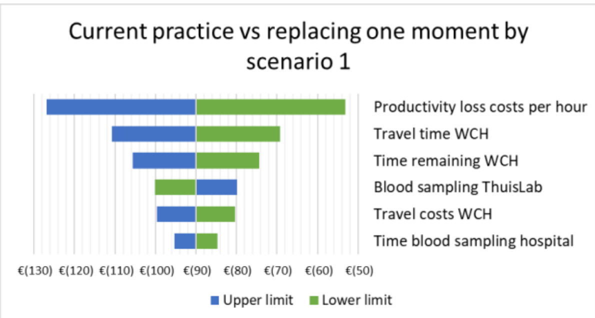


Fig. 1A. Tornado chart current practice vs replacing one moment by scenario 1

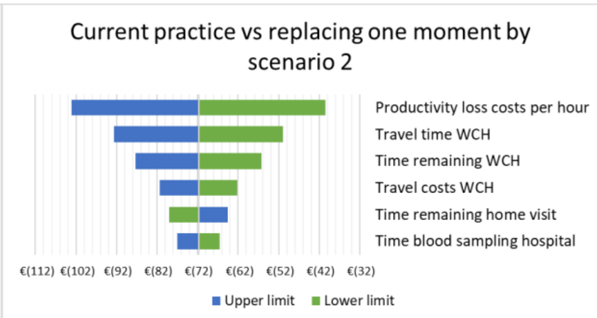
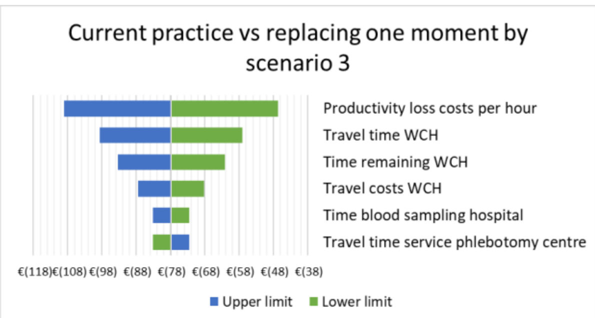


Fig. 1B. Tornado chart current practice vs replacing one moment by scenario 2



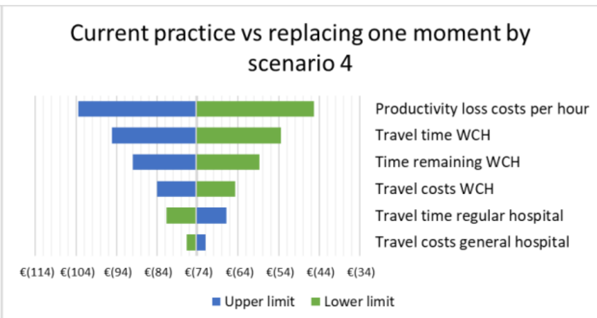


Fig. 1C. Tornado chart current practice vs replacing one moment by scenario 3

Fig. 1D. Tornado chart current practice vs replacing one moment by scenario 4

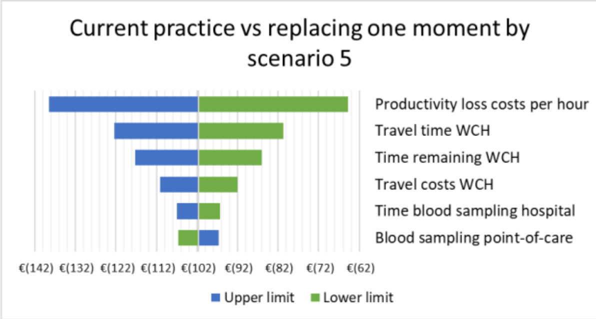


Fig. 1E. Tornado chart current practice vs replacing one moment by scenario 5

Results one-way sensitivity analysis with two replacements of the current scenario

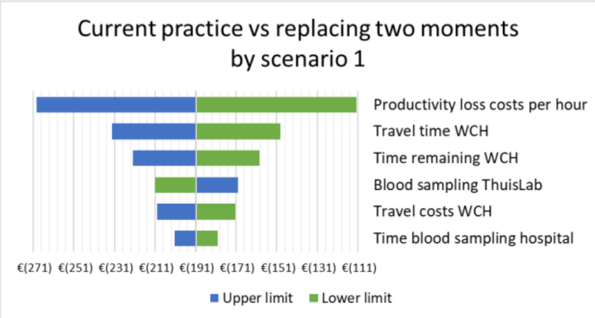


Fig. 2A. Tornado chart current practice vs replacing two moments by scenario 1

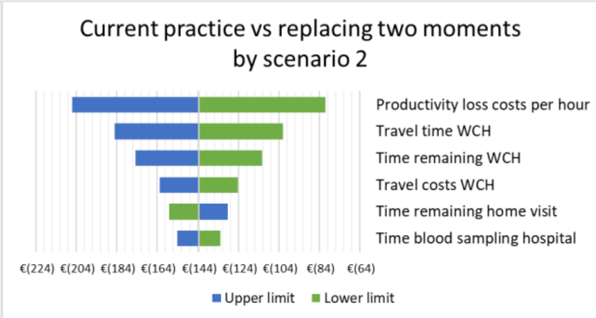


Fig. 2B. Tornado chart current practice vs replacing two moments by scenario 2

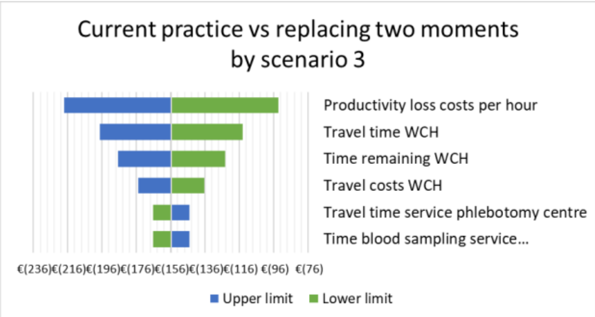


Fig. 2C. Tornado chart current practice vs replacing two moments by scenario 3

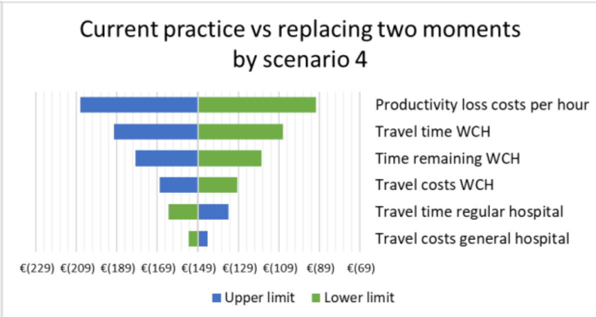


Fig. 2D. Tornado chart current practice vs replacing two moments by scenario 4

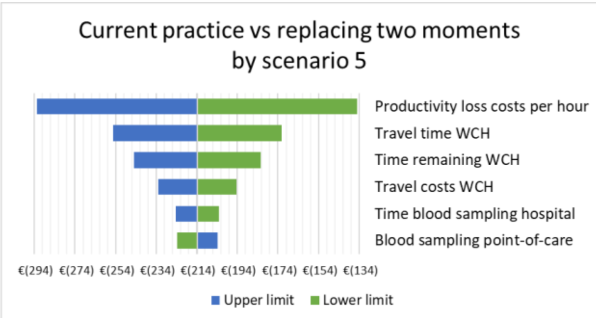


Fig. 2E. Tornado chart current practice vs replacing two moments by scenario 5