Assessing automation in infusion therapy: a comparative time model of nurse workload

Martijn Knol, MSc; Ymke T.A. Janse, MSc; Dr. Getty Huisman-de Waal, PhD; Leonie van Houten, MA; Martijn de Groot, PhD.

Katara Care B.V. Groningen, The Netherlands

SUMMARY

Infusion therapy is essential in hospital care but places a high workload on nurses due to manual tasks and frequent alarms. As healthcare costs rise and staff shortages grow, the need for more efficient healthcare delivery, including in infusion therapy, is becoming increasingly urgent.

The Ivy Duo+ is an infusion pump specifically designed to automate routine tasks and minimize interruptions. A task-based model was developed to compare conventional infusion pumps with the Ivy Duo+ in a typical care setting where patients receive continuous intravenous fluids alongside at least three intravenous medication administrations per day, called "*Fluid Infusion, Three or more Medications*" (FITM) in this white paper.

The model estimates that the Ivy Duo+ reduces nursing time spent on infusion-related tasks by approximately 30 minutes per FITM patient per day, mainly by eliminating manual steps during medication switches and reducing the need to respond to alarms. A clinical study at Radboudumc is planned to investigate the nurse workflow and workload on conventional infusion pumps in practice.

Introduction

Infusion therapy is the injection of medication or fluid directly into the body over a longer time period. Infusion therapy is of high importance, and is an essential part of modern healthcare, making it a common procedure in hospital wards for all types of patients (1,2). Infusion therapy is widely used because it supports critical physiological functions like fluid balance and drug delivery (2–4).

In Western healthcare, using infusion pumps is now standard practice, replacing older methods like gravity drip due to the need for precision, safety, and consistency (5,6).

Modern infusion pumps, including syringe, volumetric, and elastomeric types, offer accurate flow control, integrated alarms, and, in some cases, drug error prevention systems (7,8). Syringe pumps are best for low-volume, high-precision delivery; volumetric pumps are used for general high-volume applications; elastomeric pumps are portable but less accurate (9,10).

Problems in infusion therapy

High workload

One of the major problems in current infusion therapy is the high workload it places on nurses, especially in systems already strained by staffing shortages (5,11,12). High workload is frequently cited as a reason why nurses leave the profession (13). Reducing workload is therefore a necessary step in addressing this growing issue.

Infusion tasks are time-intensive. Routine actions like preparing and administering medications multiple times a day, and responding to alarms take up a significant portion of a nurse's shift (14,15). Many pumps lack automation or features that reduce manual work. For example, to administer medications, they have to walk to the medication room, retrieve or prepare the medication, walk to the patient room, program the pump, and later return to flush the line and restart the fluid therapy once the medication is finished.

High alarm frequency

Alarm frequency is another key issue. Pumps frequently trigger alarms for minor events like short duration kinks in the line or slight patient movement (16). Two examples of alarms that occur frequently are air-in-line alarms and occlusion alarms (16). These alarms often feel unnecessary, creating frustration for both staff and patients due to the constant beeping sounds and the high time expenditure. The constant interruptions contribute to alarm fatigue, where nurses become desensitized and respond more slowly or improperly (17).

Problems in healthcare systems

Increasing financial strain

The need for more efficient infusion therapy is reinforced by growing socio-economic pressures on healthcare systems. High healthcare costs are a concern not only in the Netherlands, but across many countries (18,19). To address this, the Dutch government aims to limit healthcare spending while maintaining care quality (20).

In US hospitals, labor costs alone account around 60% of total expenditures, making them the largest cost driver in healthcare Figure 1 (21). This creates a strong incentive to reduce staff workload where possible.

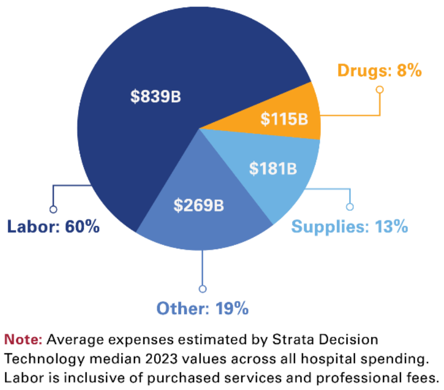

Figure 1. Cost distribution across hospitals in the US (21).

Workforce shortages

Besides being costly, healthcare personnel are increasingly scarce (11,22). The aging population in Western countries leads to more patients needing care, while the workforce providing it is relatively shrinking (23). In the EU, there is currently a shortage of 1.2 million doctors, nurses and midwives, with the WHO estimating a global shortage of 4.5 million nurses in 2030 (22,24). As one study notes, "*It is seemingly evermore improbable that globally, we will be able to recruit into fixing the nursing workforce problem*" (13).

Technology as a solution to healthcare problems?

With increasing demand due to the ageing population, rising costs, and growing workforce shortages, the need for structural solutions in healthcare has become urgent. And indeed, according to the Wetenschappelijk Raad voor het Regeringsbeleid (WRR), the current growth in healthcare demand is unsustainable given limits in funding, workforce capacity, and societal support (25). Simply expanding the system is not viable. By 2060, one in three people would need to work in healthcare if current trends persist (25). While the report warns that technological progress can drive up costs by expanding what is medically possible, it also acknowledges that technology can support smarter organization of care (25). The Dutch government has also recognized this potential, allocating €48 million from the Integral Care Agreement (Integraal Zorgakkoord, IZA) to a research program focused on workload-reducing interventions and technologies (26).

This is not a local insight. The World Health Organization and the European Commission both highlight workforce shortages as a major barrier to sustainable healthcare delivery in the coming decades (22,24). Meanwhile, the McKinsey & Company stresses that tech enablement and automation can help improve efficiency in care delivery, potentially contributing significantly to minimizing the workforce gap (27).

The Ivy Duo+

With the aim of reducing the aforementioned problems, the Ivy Duo+ was developed. The Ivy Duo+ is a new volumetric infusion pump designed to reduce nurse workload by automating tasks, minimizing alarms, and simplifying infusion workflows.

At the core is its DuoSyringe technology, which separates the fluid intake from the sources from the patient line by a set of valves, as can be seen in Figure 2. This enables automatic source switching and removes air bubbles without interrupting therapy or triggering alarms, eliminating the need for a drip chamber, and therefore reducing complexity in the workflow of nurses.

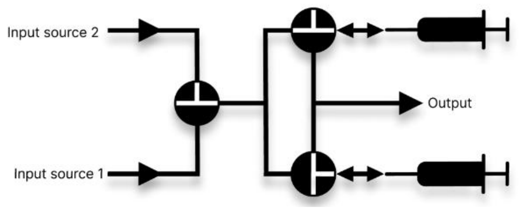

Figure 2. The mechanism of the DuoSyringe technology.

The pump integrates with a docking station that can be attached to an infusion pole or stand freely, and which holds fluid bags or bottles and charges the device. Nurses can schedule infusion therapy for up to 26 hours in under a minute using the built-in touchscreen and department-specific templates, cutting down repetitive tasks like priming, flushing, and switching infusion bags (Figure 3).

Figure 3. The GUI of the Ivy Duo+, showing the planning capabilities.

Design choices in the administration set such as an infusion line with high rigidity aim to reduce occlusion alarms. Together, with scheduled therapy and the automatic air removal, these features are designed to cut alarm fatigue and reduce manual workload.

Nursing time spent on infusion therapy: current state and modeled estimate

Target patient group: "FITM" patients

The Ivy Duo+ is designed to reduce nursing workload across a range of patient profiles, with the greatest time savings expected in patients receiving continuous intravenous fluids combined with at least three intravenous medication administrations per day. In this white paper, these patients are referred to as "Fluid Infusion, Three or more Medications" (FITM). All fluids and medications for FITM patients must be administered through a volumetric infusion pump.

According to the nephrology departments of Radboudumc and UMCG, FITM patients are frequently encountered in daily practice. However, further research is needed to determine the exact number of patients receiving this type of infusion therapy. While the Ivy Duo+ can also save time for other patient groups, including those receiving two daily medication administrations, the model in this white paper focuses specifically on FITM patients.

FITM regimens involve a high number of manual, time-consuming tasks. Continuous fluid administration often results in frequent alarms, requiring nurses to interrupt other activities, walk to the bedside, resolve the issue, and return. Furthermore, each medication administration involves walking to the medication room, preparing or retrieving the medication, programming the infusion pump and starting the medication administration, and later flushing the line and restarting fluid therapy. This repetitive sequence presents a clear opportunity for time savings through automation.

Current workload of nurses: literature

Published data on the time nurses spend on infusion therapy is limited, in part due to the complexity of clinical workflows. Nurses care for multiple patients simultaneously, often multitasking, and time spent walking to and from patient rooms is difficult to categorize (28).

Despite these limitations, the same study reported that during a 4-hour observation period, nurses averagely spent approximately 26 minutes on medication-related tasks, including preparing and retrieving medication, even in non-complex cases (28). However, this was not exclusively medication given through infusion therapy. This measurement was the average of 79 different 4-hour measurements, all on different time slots and days.

Another study focusing on chemotherapy reported that nurses spent an average of 129,7 minutes per patient per day on infusion-related care (14). While this time spent also included checking vital signs, and it was focused on chemotherapy instead of the FITM patient group, it indicates the substantial workload infusion therapy can create.

Current workload of nurses; Radboudumc

Due to limited data in the literature, additional information was collected in collaboration with the Radboudumc. A nurse survey (N=51) conducted by the Health Innovation Labs at the Radboudumc indicated that nurses spend roughly 30 minutes per patient per *shift* on tasks related to infusion therapy (data available upon request). While it is data based on personal experiences, it serves as a clear indication of the high workload related to infusion therapy.

Workload modeling (method)

To quantify the time nurses spend on infusion therapy, a detailed task-based model was developed, and peer reviewed by, associate professor Appropriate Surgical Care, Getty Huisman-de Waal (Appendix A). The model represents a typical scenario in which a patient receives at least three intravenous medication administrations alongside intravenous fluids like NaCl 0,9% or Glucose 5%.

The scenario reflects standard clinical nurse workflows, including infusion pump setup, intravenous medication switches, alarm handling, and fluid management. In the model, the workflows of two infusion pumps were compared. These were a conventional volumetric infusion pump, and the Ivy Duo+, both with simulated workflows tailored to the infusion pumps.

Actions not expected to vary between devices, such as EPD interactions, checking the infusion state every shift, and changing clothes, were excluded. Time estimates were gathered through measurement using a stopwatch during simulated use with real pumps in an office setting, using real administration sets, and fluid sources, and following official hospital protocol. The actions were performed by, usability expert, Ymke Janse. These results were supplemented with data obtained from prior usability testing with nurses.

The workflow involved a total of 781 actions over a period of 6,4 days. Some actions only occur once in this model, like infusion pump setup, replacing the administration set, and ending infusion. Other actions repeat every day, or multiple times a day. To calculate the average time spent per category per 24 hours, time spent on categories from all 6,4 days were summed, and divided by 6,4. For analysis, tasks were grouped into three categories, as shown in Table 1.

Table 1. Modeled time spent on infusion tasks using conventional infusion pumps on infusion therapy tasks in a typical 24-hour period (the total workflow divided by 6,4) (Appendix A).

Category	**Time spent in minutes**
Setting up infusion pump, replacement of the administration set, ending infusion. (infusion general)	3,0
Time spent on alarms	28,5
Time spent on medication switches	20,0
Total	**51,4**

On average per 24h, most time is spent on alarms and medication switches due to their frequency and the steps involved, along with the time-consuming walking movements to and from the patient. Infusion setup and shutdown are less time-consuming, as they only occur once during a patient’s stay in this model.

The scenario includes only the three most frequent alarm types (air-in-line, occlusion, and empty infusion bag/upstream occlusion) and excludes alarms that occur less regularly or vary widely between hospitals (empty battery, check set, door open).

Nursing time spent on infusion therapy: Ivy Duo+ and modeled estimate

Simulation testing in Radboudumc

An early indication that the Ivy Duo+ could significantly reduce nursing workload came from simulation testing conducted by Radboudumc's Health Innovation Labs in 2022. In these tests, nurses performed typical infusion-related tasks such as administering antibiotics and handling alarms, using both conventional pumps and the Ivy Duo+.

Limitations of these measurements were that nurses had little practice with the Ivy Duo+, and it was a simulation of only 2 hours of infusion related tasks limited to a single infusion pump (instead of multiple pumps as would be the case in a real-life situation).

Despite these limitations, the Ivy Duo+ consistently enabled faster task completion, largely due to automation features that reduced manual steps and interruptions. While the scenarios were controlled and limited in scope, the results suggested time savings of over 30 minutes per patient per day.

Reduction in workload based on modeling

To more precisely quantify the potential impact, the Ivy Duo+ was evaluated using the same workflow model developed earlier for conventional pumps (Appendix A). The task-based model outlines every relevant step across a 24-hour care period for a patient receiving three or more medication administrations. This includes setup, medication switches, alarm handling, and fluid management. The model not only replaces the conventional pump with the Ivy Duo+, but also includes slight workflow adjustments, such as using a larger medication fluid bag.

Each task in the care path was re-timed using the Ivy Duo+ under the same assumptions and conditions. This allowed for a direct comparison of time spent using current pumps versus the Ivy Duo+. In this model, it is assumed that no time is saved on the unmodelled tasks. The results of the time spent on the different categories using the Ivy Duo+ can be seen in Table 2.

Table 2. Modeled time spent/saved on infusion tasks with conventional pumps and the Ivy Duo+ per patient per day (Appendix A).

Category	Time spent current (min)	Time spent Ivy Duo+ (min)	Time saved in minutes
Infusion general	3,0	3,3	**-0,3**
Time spent on alarms	28,5	10,9	**17,5**
Time spent on medication switches	20,0	4,5	**15,5**
Total	**51,4**	**18,7**	**32,7**

As outlined in Table 2, more time was spent on infusion therapy by using the conventional pump, when compared with the Ivy Duo+. While 0,3 extra minutes are spent on setting up the infusion, time savings came from the reduction in alarms and the automation of the medication switches.

In this model, 17,5 minutes of nurse time were saved by the reduction of alarms, which normally require nurses to walk to the device and perform manual recovery steps. Some time was still spent on bag empty alarms, as these NaCl fluid bags still had to be replaced by nurses. As automation switches are completely automated, 15,5 minutes were saved on these steps in this scenario.

Discussion

Accuracy and realism of the estimate

The estimate of 30 minutes saved per FITM patient per day is based on detailed workflow modeling that reflects realistic hospital scenarios. Although the data stems from simulation rather than live clinical observation, the tasks were timed using actual equipment and supplemented with input from usability studies and reference materials such as online nurse training videos. This approach provides a solid basis for estimating time savings within a realistic range. However, to validate these findings, live clinical observation is required.

Further validation of impact

To validate the estimated time savings of the Ivy Duo+, a clinical study will be conducted by

IQ Health in collaboration with Health Innovation Labs (HIL) at Radboudumc, at two different nursing wards. IQ Health (Radboudumc) will act as principal investigator. The study investigates the infusion therapy related nurse workload for nurses caring for FITM patients using conventional pumps.

The main question is how much time and effort nurses spend per shift when using the conventional pumps, including time spent handling alarms and therapy-related tasks. Nurse experience, including satisfaction with the pumps, the experienced workload, sleep disruptions of the patient, usability and acceptability, will also be assessed through questionnaires or interviews.

The hypothesis is that nurses have a significant workload due to frequent alarms (e.g. air-in-line, occlusion, KVO) and a plethora of manual steps such as planning, switching, and flushing. This expectation is based on prior time measurements at Radboudumc using conventional pumps and input from Key Opinion Leaders (KOLs), along with the results from the modeling described in this white paper.

The study is a baseline measurement of the current clinical setting of infusion therapy.

In the study, baseline data on current practice is collected through observations, log data, and interviews or surveys. Results will be processed to determine the impact on workload and this will be documented in a clinical report for publication.

The investigation plan will be submitted to the METC once safety testing is complete. The study is Health Holland-funded in the project PRIMEFIT. The results of this study will be used to verify, refine, and implement the functional and usability requirements of infusion technology, the Ivy Duo+, under real-world hospital conditions.

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Authors

Martijn Knol, MSc, is a biomedical scientist and worked as project engineer on the Ivy Duo+. He was involved across several departments, working on the Clinical Evaluation, Finance, Operations and R&D. With a scientific background, he contributed to bridging technical development and practical implementation.

Ymke Janse, MSc, is a biomedical scientist and project manager at Katara Care. She focused on involving users in the product development of the Ivy Duo+ to ensure usability and safety of the product. Her experience in conducting scientific research, including usability studies with patients, supports the development of the Ivy Duo+.

Dr. Getty Huisman-de Waal, PhD, is a nurse scientist and associate professor at Radboudumc, with a research focus on person-centered care, appropriate nursing care. Her work bridges clinical practice and academic research to improve healthcare quality and empower both patients and professionals.

Leonie van Houten, MA, is a design innovator at Health Innovation Labs and a registered nurse (HBO). With a focus on translating the needs and wishes of healthcare professionals and patients into innovative development opportunities, Leonie combines her practical experience with an innovative mindset to drive meaningful advancements in healthcare technology.

Martijn de Groot, PhD, is managing director at Radboudumc Health Innovation Labs. He has a vocational background in biology, education, and medical science and has worked on different spearheading positions as researcher, teacher, and innovator at UMCG, Hanze University, and Radboudumc.

Appendix A

Table 3. Overview of time spent on different categories and action groups. Based on step-by-step modeling, the table below shows an average period of 24h taken from the entire 6,4 days. Raw data available upon request.

Action group	**Category**	**Time spent in minutes (conventional)**	**Time spent in minutes (Ivy Duo+)**
Preparing and priming infusion pump	Setting up infusion pump, replacement of the administration set, ending infusion. (infusion general)	1,3	1,2
Setting infusion pump	Setting up infusion pump, replacement of the administration set, ending infusion. (infusion general)	0,2	0,4
Medication administration (1st moment)	Time spent on medication switches	1,1	0,0
Setting infusion pump / medication administration (1st moment)	Time spent on medication switches	6,4	4,5
Air in line (1/3)	Time spent on alarms	4,2	0,0
Downstream occlusion (1/3)	Time spent on alarms	1,1	0,0
Air in line (2/3)	Time spent on alarms	4,2	0,0
Medication administration (2nd moment)	Time spent on medication switches	7,3	0,0
NaCl bag empty (1/2)	Time spent on alarms	7,5	5,8
Downstream occlusion (2/3)	Time spent on alarms	1,1	1,1
Air in line (3/3)	Time spent on alarms	4,2	0,0
Changing infusion set	Setting up infusion pump, replacement of the administration set, ending infusion. (infusion general)	1,0	1,1
Downstream occlusion (3/3)	Time spent on alarms	1,1	0,0
Medication administration (3rd moment)	Time spent on medication switches	5,2	0,0
NaCl bag empty (2/2)	Time spent on alarms	5,3	4,1
Shutting down infusion pump (patient no longer requires infusion therapy)	Setting up infusion pump, replacement of the administration set, ending infusion. (infusion general)	0,5	0,5
Total		**51,4**	**18,7**