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Optimising pharmacy processes in medication delivery service through digitalisation and automation

Kian Hong Hong Ng , Wen Jun Tiew, Yook Ting, Amanda Woo, Wei Xiong, Nathaniel Lim, Tou Teik, George Lim, Arleen Susan Baskaran

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ABSTRACT

The rapid expansion of medication delivery service (MDS) during COVID-19 created many new roles in the pharmacy which are manpower intensive and not sustainable as pharmacy resumes counter collection services. To keep MDS operations sustainable, we identified the need to streamline and automate processes which are manual and repetitive. We seek to determine if the Plan, Do, Study, Act (PDSA) cycles would effectively reduce the man-hours required for the MDS over two phases in 1 year. Phase 1 involved digitalisation of order taking and automation of the data entry process. Phase 2 involved automating the order generation and accounting process to replicate the patient information matching task which was performed manually during bagging and dispatch of delivery orders. The baseline period for this study was from December 2020 to January 2021. The results following implementation of PDSA cycles in the respective phases were collected between January 2021 to June 2021 and July 2021 to December 2021. The average time taken for data entry per delivery order reduced from a range of 0.5 to 2.15 min to 0.08 to 0.1 min depending on the ordering method ($p<0.05$). The average time taken for bagging and dispatch per delivery order shortened from 2.7 min to 0.28 min ($p<0.05$). The improvements were sustained and cumulatively contributed to 11.8-man-hour savings. The impact of the interventions was discussed. As MDS gains prominence as an important alternative for medication collection due to its rapid expansion due to COVID-19, it is crucial for the pharmacy to expand its capacity and information technology capabilities to cope with higher workload from both MDS and walk-in patients.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Digitalisation and automation in pharmacy services, such as robotic dispensing systems and electronic order integration, improve efficiency, reduce errors, and free staff for patient care, particularly during crises like COVID-19.

WHAT THIS STUDY ADDS

⇒ This study uniquely demonstrates low-cost automation (e.g., Excel macros, SikuliX) as a feasible alternative to expensive systems, achieving 11.8 man-hour savings/day with minimal capital expenditure. The integration of barcode scanning and next-day delivery models further advances real-world solutions for accuracy and scalability, aligning with calls for adaptable, crisis-ready pharmacy workflows.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study underscores the need for healthcare systems to prioritize IT infrastructure and staff training in digitalization, informing policies that support scalable, crisis-resilient pharmacy services while maintaining patient access during emergencies like pandemics.

PROBLEM

The rapid expansion of medication delivery service (MDS) during COVID-19 created new work processes in the pharmacy which are manpower intensive and not sustainable as pharmacy resumed counter collection services. Although MDS was meant to decant patients home after their consultation, a greater number of orders taken meant more rostered man-hours were required for the downstream processing.

Both MDS and counter collection tap on the existing pharmacy processes for keying, packing and dispensing which have been optimised through the implementation of Outpatient Pharmacy Automated System previously.[1] MDS requires an additional 18 man-hours on the roster for the new MDS processes. Due to the ongoing pandemic, it was inevitable for staff attrition due to COVID infection to also affect the overall pharmacy operations.[2]

Previous efforts were targeted at promoting MDS through adoption of digital order-taking platforms.[3–5] Incorporation of delivery orders from digital platforms offered insights on the potential for digitising all incoming orders to streamline information transfer for downstream processing. There is a growing body of evidence which demonstrates the benefits of process automation in terms of productivity, cost savings and improved accuracy.[6–9] Noting that the additional work processes were

Pharmacy, Changi General Hospital, Singapore

Correspondence to
Kian Hong Hong Ng;
ngkianhong1991@gmail.com

manual in nature, the project team can replicate similar successes by identifying suitable candidates for automation to optimise the MDS operations while ensuring accuracy and freeing up valuable human resources for patient care activities.

This project aimed to reduce the man-hours required for these additional MDS processes by 50% within a 1-year intervention time period. As there were no previous data for these additional MDS processes, the aim is to compare the average time taken for the identified processes before and after the interventions.

BACKGROUND

Changi General Hospital (CGH) is a public hospital serving the southern and eastern parts of the island. It is one of the largest hospitals in Singapore, with a capacity of over 1000 beds.[10] The hospital began to rapidly expand pharmacy processes for MDS during the first quarter of 2020 to cope with the disruptions from the COVID-19 pandemic.[11 12] Demand for medication delivery quickly picked up when the local government raised the Disease Outbreak Response System Condition to orange in February 2020 and subsequently implemented the 'circuit breaker' in April 2020 to control COVID-19 spread. Members of the public were advised to minimise movements and interactions in public and private places and to remain at home unless for essential purposes.[13 14]

On a national level, delivery service fees were waived by public healthcare institutions for patients on prescription medicines to allow patients to avoid travelling to healthcare facilities.[11] Close to 395 000 medication deliveries were made from 1 February to 19 August 2020. An average of 3200 deliveries were made in August 2020, a 10-fold increase from before the pandemic started.[12 15]

The outpatient pharmacy processed an average of 5200 deliveries per month between April to June 2020, an eight-fold increase relative to the previous quarter (figure 1). This delivery load sustained and even escalated to an average of 7800 deliveries between October 2020 to March 2021. The numbers only began stabilising from April 2021 onwards, averaging 5500 deliveries monthly as pharmacy ceased offering urgent same-day or next-day delivery options and introduced a daily cap to the number of deliveries. The intention was to transit patients back to collecting medications in pharmacy as the COVID situation continued to improve during phase 3 reopening.[16 17] During this transition, resources were redirected to support pharmacy operations for physical collection. MDS operations were not sustainable if the numbers remained high.

The outpatient pharmacy serves patients from all SOCs within the Medical Centre. Patients who had same-day consultations or walk-in patients could opt for MDS by submitting their prescriptions or medication balance memo for order taking at the MDS counter outside the pharmacy. Otherwise, patients could call in to the pharmacy to place orders. Orders would then be recorded onto paper order slips. For digital order submission, they could log in to the digital health app, Health Hub or Health Buddy or submit via FormSG, which was a secure digital form builder platform that enabled the pharmacy to customise a delivery form for data collection.[3 4]

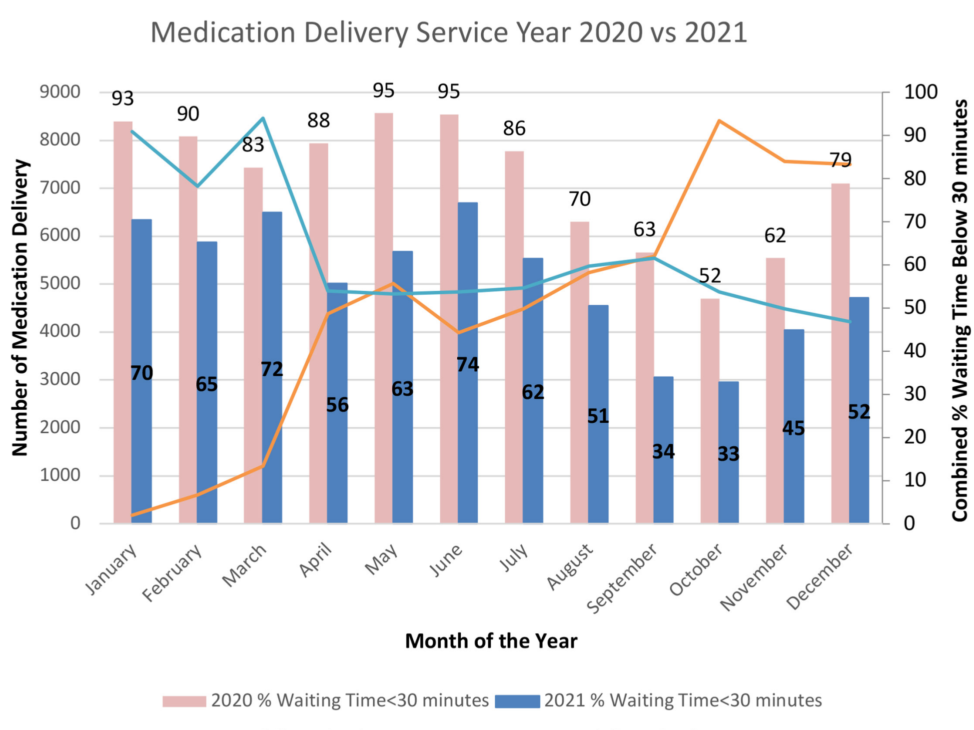

Figure 1 Monthly delivery load trend versus pharmacy waiting time trend in 2020 and 2021.

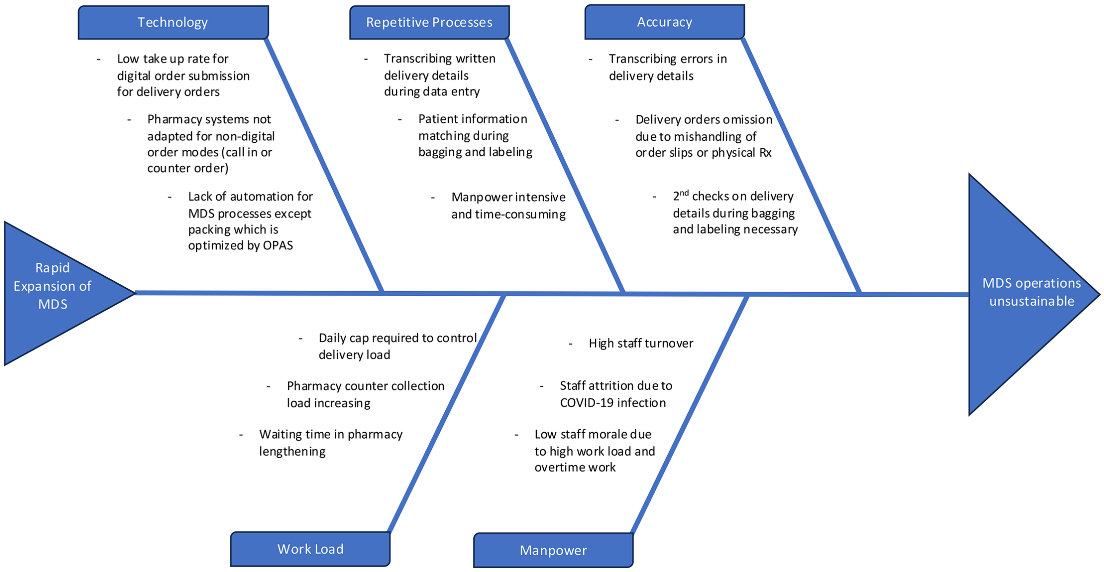

Figure 2 Fish bone Diagram identifying potential root causes for unsustainable medication delivery service (MDS) operations.

The fish bone diagram (figure 2) summarises the issues encountered by the outpatient pharmacy in sustaining MDS operations.

We defined the manpower input based on the average time taken per delivery for each of the identified processes in MDS. A process mapping was done to broadly define the main processes which were involved in a delivery order (figure 3). Within each main process, tasks which bear characteristics that promote automation were identified.

These identified tasks, although clearly defined in job scope, are manual and highly repetitive. There was potential for existing information technology (IT) systems to provide patient details if delivery details were recorded electronically instead. Through a retrospective analysis of our delivery transaction record, we established that most delivery addresses are consistent with the database in the outpatient appointment system (OAS) which is linked to our prescribing and pharmacy system. Therefore, our interventions could potentially tap into the OAS to replicate and reduce work done by these existing roles.

Our project aim was to substantially reduce the overall man-hours required for these MDS processes through digitising delivery details and automating the work done in these roles. We also aim to simplify the workflow within each process and eliminate manual roles through our interventions.

MEASUREMENT

Between December 2020 and January 2021, a time motion study was done to collect baseline data for the MDS processes. Pharmacy staff who were rostered for the respective MDS duties were instructed to record the number of delivery orders processed during their rostered time slots. The average time taken per order would then be calculated based on the average number of orders completed within the rostered duration. The exercise was conducted over a 1-month period to include all eligible pharmacy staff who could be involved. Self-reporting was chosen over the observation method for data recording

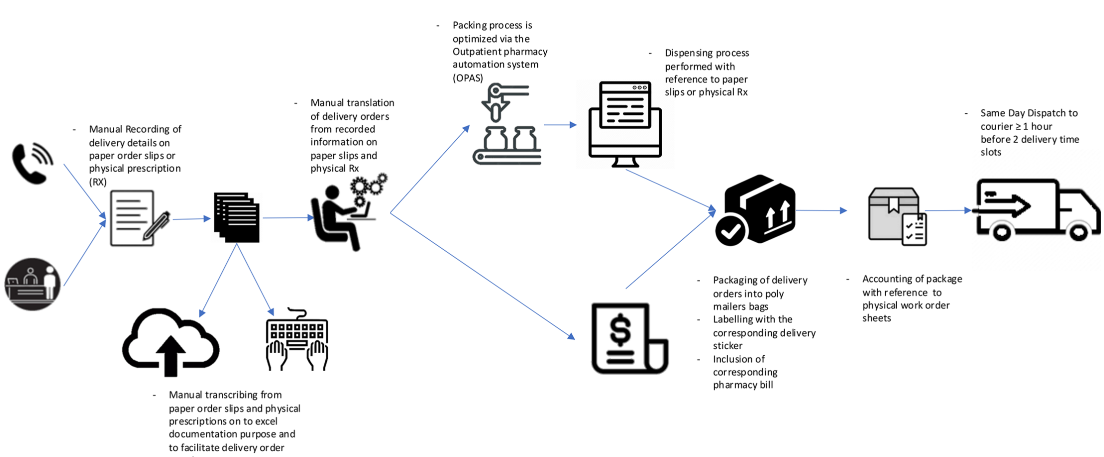

Figure 3 Medication delivery service (MDS) process mapping in a flow Chart.

feasibility purposes, and a longer period was considered to allow for a fairer representation of the overall productivity under the current processes. This also helped to minimise the Hawthorne effect.[18]

The productivity post-intervention was measured based on the time taken to process each delivery order either by the rostered staff using the digitalisation tool or the automation tools itself. Zero minutes would be recorded if the role has been eliminated due to the intervention.

DESIGN

The team was led by the pharmacist in charge of the Medication Delivery Service along with five other pharmacists who were working in the Medical Centre Outpatient Pharmacy. A software engineer from Health Services Research (HSR) provided support for this project as subject matter expert for automation. Our project sponsor was our outpatient pharmacy manager who lent us her support to engage in discussions with external stakeholders to implement legacy changes and enlist support from our Allied Health Director to expedite our IT requests with the Integrated Health Information Systems (IHIS). The implementation of our automation relied on our highly adaptable outpatient pharmacy team.

We reviewed the baseline data that was collected and rationalise that the implementation timeline for this Quality Improvement (QI) project would be in two phases, over a period of 1 year. Rapid Plan, Do, Study, Act (PDSA) testing cycles were adopted in our approach.[19] The intent was to fully digitise the delivery order details in the upstream processes in the first phase, then observe the impact on the downstream processes before formulating new interventions. We engaged the pharmacy staff involved in these roles on the ground to ensure their active participation and ownership for successful implementation.

STRATEGY

Intervention phase 1 (January 2021 to June 2021)

Patient Registration system

Plan, Do, Study, Act (PDSA) cycle 1

An electronic form was created using macros in Excel to eliminate order slips recording and the additional step of transcribing electronically.[20] The recorded information was stored electronically on order submission. Delivery details could be auto-populated from database records the next time a patient identification number (ID) was entered.

Plan, Do, Study, Act (PDSA) cycle 2

Functional enhancements were added to improve usability and robustness. An auto-backup feature prevents data loss. An overwrite database function allowed users to update patient particulars if changes were noted. Confirmation prompts were added to remind users to verify information. Shortcut keys such as ‘details as per OAS’, ‘fridge item’ tick box and hot keys for ‘clear form’ were added on the electronic form to reduce repetitive data entry.

SikuliX

Plan, Do, Study, Act (PDSA) cycle 1

For same-day clinic patients, the patient details on the physical prescription itself were also available on OAS. In collaboration with HSR, a visual automation tool called SikuliX was trialled to automate the data entry process. This programme would identify and interact with graphical user interface (GUI) components on the OAS to extract and input delivery details onto Excel records based on the list of patient IDs collated from the submitted physical prescriptions.[21]

Plan, Do, Study, Act (PDSA) cycle 2

Ground user feedbacks that the SikuliX programme would halt unexpectedly during auto-population of delivery details. Script modifications to account for specific conditions or inter-variability in interface across computers were executed with guidance from HSR’s developer to improve reliability and robustness of the process, and an auto-save function was added to prevent data loss during programme halt.

FormSG

Plan, Do, Study, Act (PDSA) cycle 1

The initial extraction process for FormSG orders was cumbersome as orders were extracted via email for printing to facilitate order screening and manual data entry subsequently. To eliminate data entry, a JavaScript application by FormSG was used to export delivery details into Excel for processing.

Plan, Do, Study, Act (PDSA) cycle 2

Email extraction and printing of FormSG orders were still necessary for downstream MDS processes. A new script application was created in collaboration with the IHIS developer to generate print-ready FormSG orders files and export delivery details into Excel, processing became instantaneous.

Intervention phase 2 (July 2021 to December 2021)

Up to June 2021, the interventions implemented during phase 1 were sustained and could maintain accuracy of delivery details. Generation of delivery labels from patients details became smoother as delivery details were fully digitised and delivery orders could be consolidated easily. However, the downstream process of bagging and dispatch was still hindered by the reliance on physical documents for patient information matching, and the generation of pharmacy bills was a potential rate-limiting step.

Under the improved workflow, prescriptions processed through SikuliX and FormSG slips were still retained for patient information matching by the ‘sealer’ before affixing the delivery label and sealing the parcel (figure 4). The inclusion of pharmacy bills in the delivery

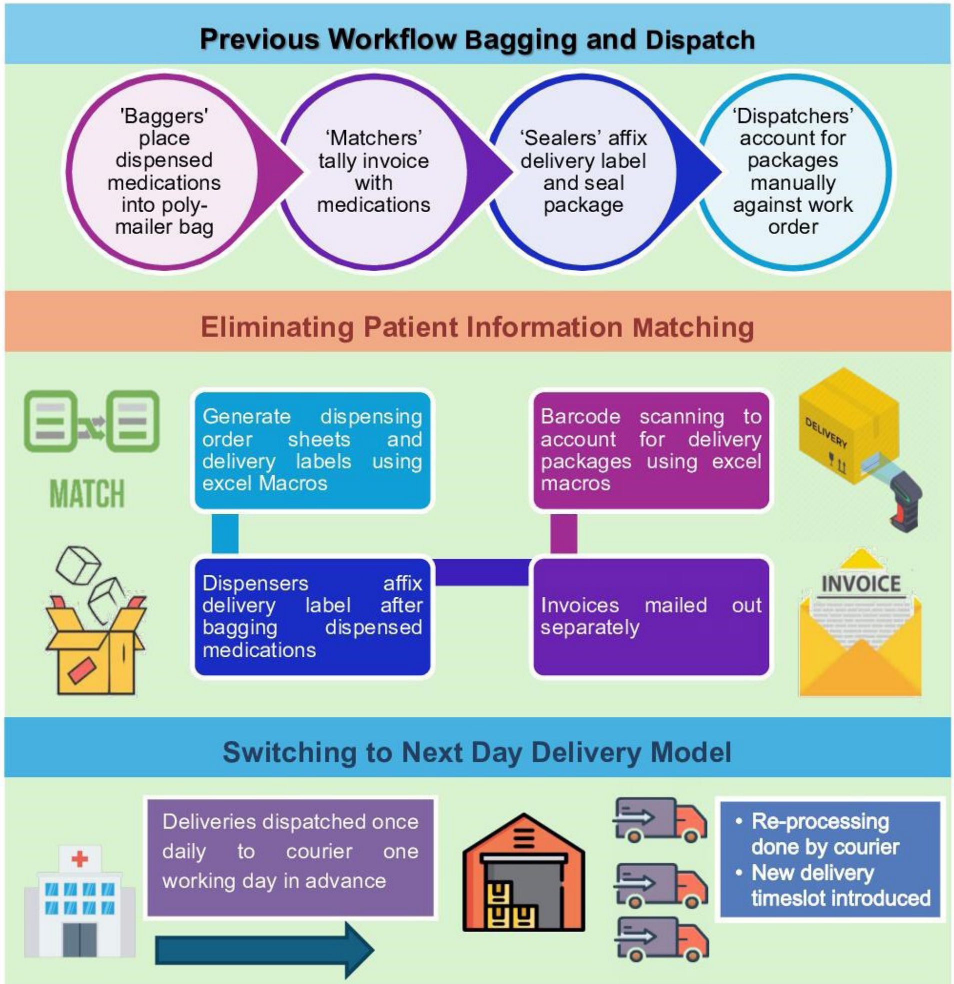

Figure 4 Quality improvement for phase 2.

parcel was still required to provide patients with price information of their delivery order(s). We identified the pharmacy billing step to be a separate process from the MDS operations that could be performed after the delivery order was keyed into the system for packing and dispensing. Hence, bagging and dispatch to assemble the delivery parcel could only start once the delivery labels are generated, delivery orders are dispensed, and pharmacy bills are printed.

1) Eliminating repetitive patient information matching

Plan, Do, Study, Act (PDSA) cycle 1: using Macros to eliminate patient information matching

Tapping on the successful use of macros in Excel in the electronic order form from phase 1, the team explored developing new macro functions by programming on Visual Basic Editor to replicate and consolidate the patient information matching function involved in the current workflow.[22]

The new macros function for the delivery transaction record in Excel enabled systematic generation of dispensing order sheets with their corresponding delivery labels. This enabled pharmacy dispensers to take over the role of 'bagger' to bag up dispensed medications and 'sealer' to affix delivery labels before sealing off the parcels. The team sought feedback from the dispensing staff to keep the workload per order sheet manageable. The consensus was to keep to a maximum of eight patients per dispensing order sheet with their corresponding delivery labels.

Separately, another new macro function for the work order Excel enabled the 'dispatcher' to scan barcodes on delivery labels to highlight the corresponding delivery order numbers on Excel when accounting for parcels prior to dispatch.

Plan, Do, Study, Act (PDSA) cycle 2: eliminating pharmacy bills in parcels

The delivery parcel could not be sealed off by the pharmacy dispenser as it was still pending inclusion of the pharmacy bill. To address this issue, the team, together with our project sponsor, engaged the stakeholders from the Business Office and Finance Department for consensus to exclude pharmacy bills from delivery parcels. Patients may access the pharmacy bills for their delivery orders and make payments electronically via the digital health app—Health Hub or Health Buddy. The pharmacy would continue to print bills and mail them out separately by post until the stakeholders were able to review and approve for the complete removal of sending out pharmacy bills to patients. Under the new workflow (figure 4), the pharmacy dispenser could seal off the delivery parcel after dispensing the medications and pasting the corresponding delivery labels.

2) Switching to the next day delivery model

Despite the automations from the earlier PDSA cycles, ad hoc new delivery requests or urgent changes to delivery timing or date were still disruptive to operations. Also, there was recurring feedback from patients regarding late deliveries and requests for earlier delivery timeslots. The current same-day dispatch-delivery arrangement involved CGH as the dispatch point. Couriers would come in at least 1 hour before each delivery time slot (2–6 PM, 6–10 PM). This model was originally preferred as pharmacy offered same day or next day urgent delivery to clinic patients during the early days of COVID-19. The project team reviewed the suitability of the current model and engaged the Agency of Logistics and Procurement Services which contracted the current vendor for courier services to explore alternatives within the scope of work in the current contract.

A new dispatch for next day delivery model was introduced in January 2022 which relocated the dispatch point to the courier's warehouse. Ambient and cold chain storage of the medication parcels were maintained in accordance with Singapore Standard 644 (SS 644): guidelines for supply and delivery of medication at the vendor's warehouse.[23] Delivery orders for all timeslots were accounted via bar code scanning by the 'dispatcher' before dispatching to the collection driver once daily in the late afternoon. Parcels were transported back to the warehouse for sorting and route planning before delivery the next working day. Couriers would collect medication parcels from the warehouse and return failed deliveries for rescheduling. Patients were advised to liaise directly with the courier for rescheduling of failed deliveries or upcoming deliveries if the delivery date was within three working days' time to reduce unnecessary follow-up processing on the pharmacy's end. Furthermore, a new delivery time slot (10 AM–2 PM) could be introduced to maximise the utility of the courier service and improve convenience for patients.

RESULTS

An independent t-test was used to determine the statistical significance of the results before and after interventions for both QI phases.

The improvement made by the respective interventions from phases 1 and 2 was represented in the control chart (figure 5) over a 1-year period.

At the end of the PDSA cycles during phase 1, the average time taken per order improved from between 0.90 and 2.15 min to between 0.08 and 0.1 min depending on the ordering method (table 1) ($p<0.05$). The variance (represented by error bar in figure 5) for the time taken for data entry from order slip using the Pharmacy Registration System (PRS) and prescription via SikuliX respectively reduced by 10%.

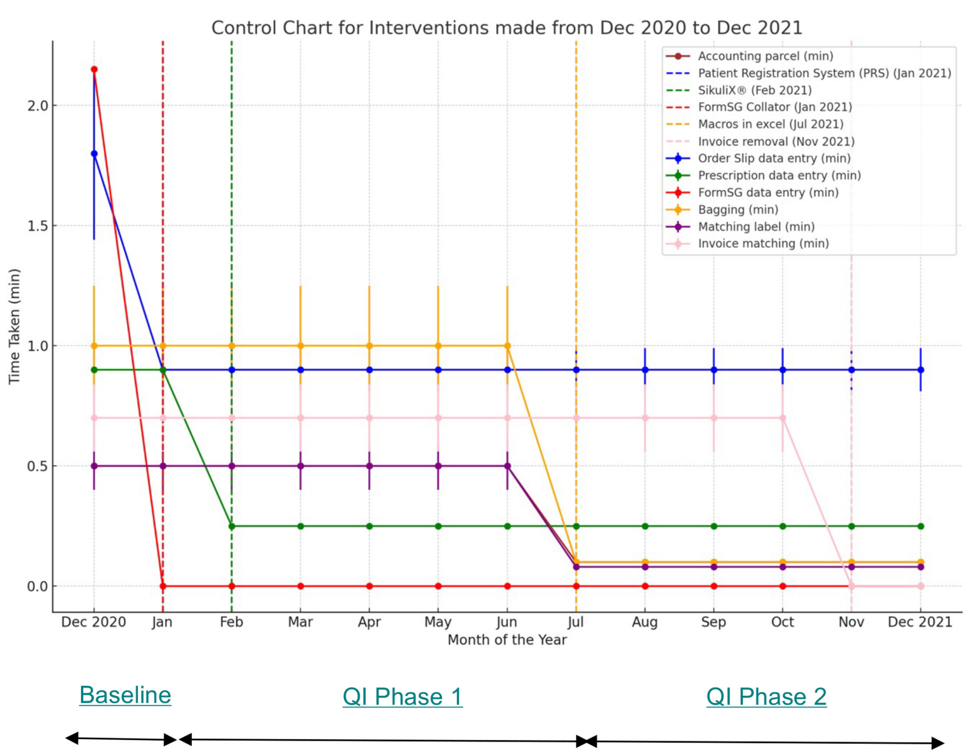

Figure 5 Progress of time taken for each medication delivery service (MDS) process after interventions.

Table 1 Average time taken for the respective medication delivery service (MDS) process with respect to the PDSA cycle

Phase 1 (January 2021 to June 2021)			
Average time taken per order (minutes)		Average number of orders to data entry per day	Average time saved per day (minutes)
Previous workflow	PDSA cycle		
Data entry from order slip	Data entry via PRS	63	56.7
1.8±0.36	0.90±0.09		
Data entry from prescription	Data entry via SikuliX	52	33.8
0.90±0.09	0.25		
Data entry from FormSG slips	Process via FormSG collator	75	161.25
2.15	0		
Total man-hour savings per day ≈ 4.2 hours			
Phase 2 (July 2021 to December 2021)			
Previous workflow	PDSA cycle	Average number of orders per day	Average time saved per day (minutes)
Bagging medications	Bagging medications after dispensing	190	171
1±0.25	0.10±0.01		
Match the delivery label to the medication	Affix the delivery label by the dispenser		79.8
0.5±0.10	0.08±0.008		
Match the invoice to the package	Post out the invoice separately		133
0.7±0.14	0		
Manual account against order paper	Barcode scan label to account		76
0.5±0.1	0.1		
Total man-hour savings per day ≈ 7.6 hours			

PDSA, Plan, Do, Study, Act.

For the second phase of QI, the overall average time taken per order for bagging and dispatch improved from 2.7 min per delivery order to 0.28 min per order ($p<0.05$). There were corresponding 15% and 10% reduction in variances for bagging of medication and matching of label with the help of Excel in macros in transaction records to consolidate the role of 'bagger' and 'sealer'.

The implementation of PRS, SikuliX and FormSG collator enabled the data entry and order collation to be more efficient and accurate. The PRS helped to digitise delivery details and eliminated additional manual transcribing from order slips. The initiation of PRS enabled pharmacy staff to perform data entry of new order requests in real time, and the creation of electronic database from PRS significantly sped up retrieval of delivery order details for patients.

The quality improvement effort from phase 2 was contingent on the adoption of the digital tools from phase 1 which enabled the full digitisation of delivery details recording. The consolidation of roles only incurred an additional 0.18-min workload per order for the pharmacy dispenser. Adopting barcode scanning of delivery labels to account for parcels on the work order Excel greatly improved accuracy, eliminated time variance and reduced time taken per order by 80%. It also promoted more autonomy for the 'dispatcher' in helping to track and reconcile missing parcels.

The switch to the next-day delivery model has reduced phone calls regarding amendment of delivery timings, rescheduling of failed deliveries and checking of delivery status. Patients would receive system-generated SMS reminders regarding their delivery on the morning of delivery, and the customer service number of the courier would be provided as well.

Overall, feedback from our pharmacy staff was positive despite many rounds of workflow changes since January 2021. Pharmacy technicians and assistants were receptive towards adopting the digital tools and even provided user feedback to further improve the user experience. Sufficient user trainings were conducted to ensure full participation from the pharmacy team. The interventions from our QI project were sustained and contributed to cumulative 11.8-man-hour savings on average per day, more than 50% of our initial project aim. Digitisation of delivery order details enabled accurate real-time tabulation and effective control of daily delivery load for manpower optimisation of MDS operations. Pharmacy could thus plan ahead for extended weekends due to public holidays whereby sharp spikes in delivery requests were usually expected or even unexpected prolonged high staff absences.

In a separate manpower project in January 2022, the streamlined MDS processes allowed for the outpatient pharmacy roster to be reorganise into four smaller teams

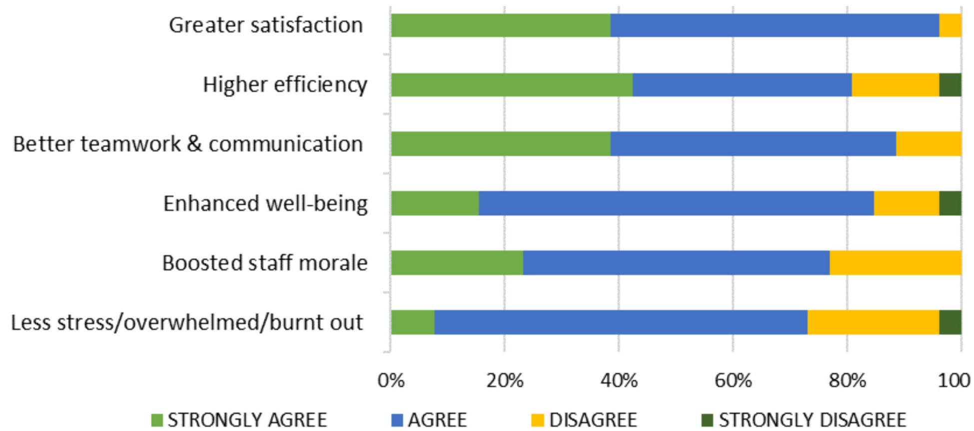

Figure 6 Survey result on staff perception towards team-based roster for medication delivery service (MDS) operations.

to cater to MDS operations on a weekly rotation. The team-based approach offered pharmacy staff respite from direct patient fronting duties, which proved effective in improving staff well-being and morale. A staff perception survey was conducted among 26 staff 1 year postimplementation. The majority of employees reported positive outcomes across all six measured aspects (figure 6). More than 90% of the staff also felt that they experienced improved satisfaction at work after starting the team-based roster.

The balancing measures tracked in this project were the average pharmacy waiting time for medication collection by month (figure 1). The manpower savings from this project were mainly targeting pharmacy technicians and assistants who were involved in either upstream or downstream of MDS operations. More than half are not involved in counter dispensing. Our team noted high turnover of pharmacist, pharmacy technician and assistants in similar proportions which could have affected the waiting time as pharmacies face declining manpower resources. The overall high turnover was found to be related to growing fatigue due to COVID-19's impact at the workplace.[24 25] There was no significant correlation found between the implementation of PDSA cycles from both phases on pharmacy waiting time.

LESSONS AND LIMITATIONS

Lessons Learnt

Our project has demonstrated the positive impacts of process automation in productivity and accuracy. The project could not have happened without inter-departmental collaboration from HSR and IHIS during phase 1 to trial out RPA via SikuliX and to develop the FormSG order extraction process respectively.

Although this project was driven by the need to reduce manpower input for MDS, the experience gained from using automation tools has led the team to spread their applications in other areas within pharmacy. A SikuliX script was written to automate data extraction from the pharmacy system for stock tallying during audits. This eliminated manually searching and recording of stock levels for each item, leading to significant time savings. Electronic forms were created using macros in Excel for the purpose of recording patient's ID when top-up prescriptions were handed over from different clinics using a time stamp. This sped up information retrieval when accounting for the possession of prescriptions before supplying top-up medications to patient. Therefore, these digital tools are versatile and can be applied in a variety of ways to improve productivity and reduce manpower hours spent on repetitive manual work in pharmacy.[26]

Gathering feedback from ground staff and regular updates on the workflow changes during roll calls was necessary to keep them engaged since the start of the project. Data-driven decision-making helped convince all parties to adopt the new digital tools quickly.

Limitations

Due to the operational nature of data collection for the MDS processes before and after the PDSA cycles, it is possible for errors arising from transcription mistakes, variability in staff efficiency and external factors involving language barriers or complex prescription orders to contribute to longer time taken for each process. Other external factors such as unanticipated system downtimes resulting in delivery data loss remained unaddressed as the back-up data needs to be reconciled manually once a downtime is identified. This underscores the need for a more robust error-handling process and improved user feedback mechanism to enable timely modifications to the Excel macros script, enhancing its reliability and minimise errors.

High cost and long lead time for system enhancements remained a major hurdle in improving productivity for new pharmacy services which emerged due to COVID-19.[26] It is important to note that no capital expenditure (Capex) was incurred to purchase new systems for this QI project. The development of these digital tools incurred man-hours from our project team, HSR and IHIS.

We believe that streamlining MDS digital platforms for patients is the long-term solution to keep MDS operations lean and sustainable. Based on the overall ease of collating patient and delivery details, Health Buddy and Health Hub are the preferred platforms because the enhanced Medicine Order Service feature allows patient to retrieve prescription records in terms of medication balance from our pharmacy systems when placing delivery orders. [27] Patient education to address potential barriers towards the adoption of Health Buddy and Health Hub is the next potential area of focus for the team.

CONCLUSION

The adoption of digital and automation tools to record delivery orders electronically was critical in enabling downstream interventions to improve the overall productivity of MDS. The key motivation behind the project was to keep MDS operation sustainable by simplifying work processes and eliminating manual roles performing repetitive tasks.

The interventions proposed required technical expertise from the HSR and IHIS for development and participation from an adaptable pharmacy workforce for successful implementation. This project demonstrated how automation could be implemented in a zero-cost manner using existing hospital resources.

The digital transformation of MDS provides insights on adjusting manpower structure to expand the scalability of MDS to cope with higher patient load in future. As MDS gains prominence as an important alternative for medication collection due to its rapid expansion due to COVID-19, it is crucial for pharmacy to expand its capacity and IT capabilities to cope with higher workload from both MDS and walk-in patients. The team is looking into system enhancements to further integrate MDS as part of the patient journey in the SOCs.

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Patient consent for publication Not applicable.

Ethics approval Not applicable.

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ORCID iD

Kian Hong Hong Ng http://orcid.org/0009-0008-3102-2954

REFERENCES

1 Cgh.com.sg. 2019. Available: https://www.cgh.com.sg/news/patient-care/better-quicker-care-at-cghs-new-centre
2 Begum S, Chua N. S'pore healthcare workers feel the strain of manpower crunch amid rise in covid-19 cases. The Straits Times; 2021. Available: https://www.straitstimes.com/singapore/health/spore-healthcare-workers-feel-the-strain-of-manpower-crunch-amid-rise-in-covid-19
3 Patients to benefit from improved medication access and better medication literacy. Singhealthacademy.edu.sg; 2019. Available: https://www.singhealthacademy.edu.sg/news/patient-care/patients-to-benefit-from-improved-medication-access-and-better-medication-literacy
4 FAQs for health buddy - singhealth. Singhealth.com.sg; 2019. Available: https://www.singhealth.com.sg/patient-care/patient-visitor-info/pages/health-buddy-faqs.aspx
5 FormSG: from idea to hit platform in a year. Gov.sg; 2024. Available: https://knowledge.csc.gov.sg/ethos-issue-21/formsg-from-idea-to-hit-platform-in-a-year/
6 Spinks J, Jackson J, Kirkpatrick CM, *et al*. Disruptive innovation in community pharmacy - Impact of automation on the pharmacist workforce. *Res Social Adm Pharm* 2017;13:394–7.
7 Schneider PJ, Pedersen CA, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: Dispensing and administration-2017. *Am J Health Syst Pharm* 2018;75:1203–26.
8 Weir NM, Newham R, Bennie M. A literature review of human factors and ergonomics within the pharmacy dispensing process. *Res Social Adm Pharm* 2020;16:637–45.
9 Zayas-Cabán T, Haque SN, Kemper N. Identifying Opportunities for Workflow Automation in Health Care: Lessons Learned from Other Industries. *Appl Clin Inform* 2021;12:686–97.
10 Hospital overview. Com.sg; 2024. Available: https://www.cgh.com.sg/about-us
11 Tiffany Fumiko Tay. Coronavirus: public healthcare institutions waive medicine delivery fees for patients. The Straits Times; 2020. Available: https://www.straitstimes.com/singapore/coronavirus-public-healthcare-institutions-waive-medicine-delivery-fees-for-patients
12 News highlights. Ministry of Health; 2024. Available: https://www.moh.gov.sg/news-highlights/details/medication-delivery
13 Risk assessment raised to dorscon orange. Ministry of Health; 2024. Available: https://www.gov.sg/article/additional-measures-introduced-with-dorscon-orange
14 Circuit breaker to minimise further spread of COVID-19. Ministry of Health; 2024. Available: https://www.moh.gov.sg/news-highlights/details/circuit-breaker-to-minimise-further-spread-of-covid-19
15 MOH. News highlights. n.d. Available: https://www.moh.gov.sg/news-highlights/details/medication-delivery-services-available-to-patients
16 MOH. News highlights. n.d. Available: https://www.moh.gov.sg/news-highlights/details/end-of-circuit-breaker-phased-approach-to-resuming-activities-safely
17 Ministry of Health. Moving into phase three of re-opening. 2024. Available: https://www.moh.gov.sg/newsroom/moving-into-phase-three-of-re-opening
18 McCambridge J, Witton J, Elbourne DR. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *J Clin Epidemiol* 2014;67:267–77.
19 Taylor MJ, McNicholas C, Nicolay C, *et al*. Systematic review of the application of the plan–do–study–act method to improve quality in healthcare. *BMJ Qual Saf* 2014;23:290–8.
20 How to use excel macros to save time and automate your work. Computerworld. n.d. Available: https://www.computerworld.com/article/1614590/how-to-use-excel-macros-save-time-automate-work.html
21 Github.io. 2024. Available: https://sikulix.github.io/docs/
22 Differences between office scripts and VBA macros - office scripts. 2023. Available: https://learn.microsoft.com/en-us/office/dev/scripts/resources/vba-differences
23 Singapore Manufacturing Federation. News. 2024. Available: https://www.smfederation.org.sg/news/new-standards-launch-guidelines-supply-and-delivery-medicon
24 MOH. News highlights. n.d. Available: https://www.moh.gov.sg/news-highlights/details/impact-of-covid-19-on-resignation-and-recruitment-of-healthcare-professionals/
25 Tan C. More healthcare workers in S'pore quit amid growing fatigue as covid-19 drags on. The Straits Times; 2021. Available: https://www.straitstimes.com/singapore/politics/more-healthcare-workers-in-spore-resigning-amid-growing-fatigue-as-covid-19-drags
26 Huang WL, Liao SL, Huang HL, *et al*. A case study of lean digital transformation through robotic process automation in healthcare. *Sci Rep* 2024;14:14626. Available: https://www.nature.com/articles/s41598-024-65715-9
27 Chian L. SGH patients can now track medication balance in-app, collect medicine from selected fscs. The Straits Times; 2022. Available: https://www.straitstimes.com/singapore/health/sgh-patients-can-now-track-medication-balance-in-app-collect-medicines-from-select-family-service-centres