# Defining the Solution …

**Proposed Solution**

AI algorithms **(SMART Calculator)** to perfect the selection of drug orders for robotic compounding based on the prescribed dosage, to reduce the amount of drug wastage due to unused portions in single/ multi-dose vials.

**Proposed Plan**

Decrease CO2e with Financial impact

Reduce activity

Reduce carbon intensity

**Plan impact outcomes**

Waste prevention and avoidance

Staff empowerment

Lean pathways

Less drug utilisation

Sustainable operational resource

**Monitoring**

**Dashboard** with **interactive real-time data visualization** – heatmaps and charts of total drug wastage plotted by time-period, reason, and drug; allows drilling into specific areas of the chart for detailed analysis.

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**TOTAL POTENTIAL WASTAGE FROM 01-APRIL-2022 TO 30-JUNE-2022**
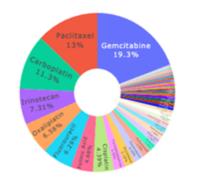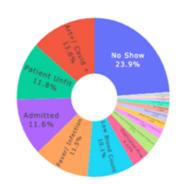
% of Total Cost By Drug, Total = $334,842

% of Total Prep Count By Drug, Total = 684

% of Total Cost By Reason

Optimizer

Optimized Order List Wastage: 0 MG

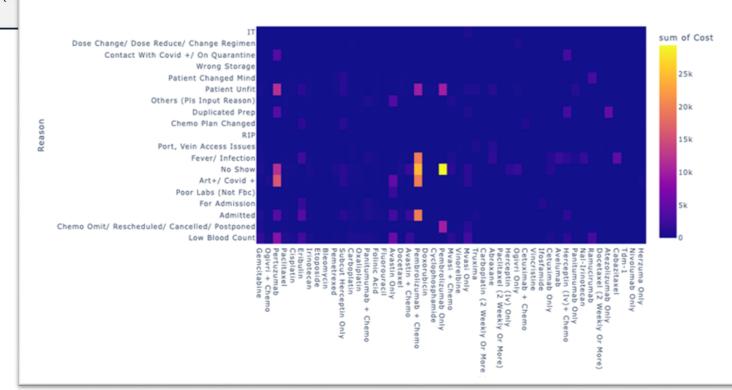| DRUG | DOSE (MG) |
|---|---|
| Gemcitabine | 1500 |
| Gemcitabine | 1500 |
| Gemcitabine | 1400 |
| Gemcitabine | 1200 |
| Gemcitabine | 1400 |
| Gemcitabine | 1500 |
| Gemcitabine | 1500 |



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Table 1A: Breakdown of the chemotherapy wastage for all 35 drugs (arranged in alphabetical order) in terms of amount (mg) and cost ($) from June 2021 to February 2022 (9 months).

| Drug | Total preparation counts | | Total amount prescribed | | Total amount available in the preparation phase[c] | Preparation phase (with vial-sharing) | | | Preparation phase (without vial-sharing) | | | Administration phase | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Amount of wastage | Cost of wastage | | Amount of wastage | Cost of wastage | | Amount of potential wastage | Cost of potential wastage | |
| | n | % | mg | % | mg | mg | $ | % | mg | $ | % | mg | $ | % |
| **All drugs (n=35)** | **52,748** | **100.00** | **28,552,830** | **100.00** | **29,322,766** | **769,938** | **1,138,068.17** | **100.00** | **8,107,326** | **3,019,919.61** | **100.00** | **1,446,493** | **909,880.90** | **100.00** |
| Atezolizumab (Tecentriq)[a] | 624 | 1.18 | 745,560 | 2.60 | 748,800 | 3,240 | 14,526.00 | 1.28 | 3,240 | 14,526.00 | 0.48 | 9,600 | 43,040.00 | 4.73 |
| Bevacizumab (Avastin)[a] | 1,918 | 3.64 | 870,907 | 3.05 | 880,400 | 9,494 | 67,166.51 | 5.90 | 7,743 | 236,966.51 | 7.85 | 24,685 | 174,646.38 | 19.19 |
| Bleomycin[b] | 140 | 0.27 | 2,973 | 0.01 | 3,375 | 402 | 1,394.45 | 0.12 | 432 | 1,498.41 | 0.05 | 196 | 679.90 | 0.07 |
| Carboplatin[b] | 4,329 | 8.21 | 1,289,093 | 4.51 | 1,341,900 | 52,807 | 3,628.43 | 0.32 | 1,065,757 | 73,229.35 | 2.42 | 63,639 | 4,372.70 | 0.48 |
| Cetuximab (Erbitux)[a] | 434 | 0.82 | 221,197 | 0.77 | 226,200 | 5,003 | 7,035.72 | 0.62 | 7,203 | 10,129.58 | 0.34 | 9,700 | 13,641.11 | 1.50 |
| Cisplatin[b] | 2,077 | 3.94 | 150,031 | 0.53 | 159,800 | 9,769 | 3,593.87 | 0.32 | 102,269 | 37,624.62 | 1.25 | 8,244 | 3,032.96 | 0.33 |
| Cyclophosphamide[b] | 1,519 | 2.88 | 1,514,129 | 5.30 | 1,621,000 | 106,871 | 1,442.76 | 0.13 | 485,871 | 6,559.26 | 0.22 | 24,336 | 328.53 | 0.04 |
| Dacarbazine[b] | 51 | 0.10 | 31,909 | 0.11 | 34,800 | 2,891 | 664.93 | 0.06 | 3,491 | 802.93 | 0.03 | 608 | 139.84 | 0.02 |
| Docetaxel[b] | 1,369 | 2.60 | 126,427 | 0.44 | 143,680 | 17,253 | 11,819.59 | 1.04 | 92,933 | 63,665.12 | 2.11 | 3,233 | 2,214.80 | 0.24 |
| Doxorubicin[b] | 1,321 | 2.50 | 108,800 | 0.38 | 113,700 | 4,900 | 1,513.12 | 0.13 | 21,250 | 6,562.00 | 0.22 | 1,546 | 477.25 | 0.05 |
| Eribulin (Halaven)[b] | 387 | 0.73 | 670 | 0.00 | 744 | 74 | 48,243.00 | 4.24 | 110 | 71,643.00 | 2.37 | 30 | 19,695.00 | 2.16 |
| Etoposide[b] | 981 | 1.86 | 141,562 | 0.50 | 151,300 | 9,739 | 901.79 | 0.08 | 43,239 | 4,003.89 | 0.13 | 3,820 | 353.73 | 0.04 |
| Fluorouracil[b] | 3,561 | 6.75 | 9,802,327 | 34.33 | 9,869,000 | 66,673 | 273.36 | 0.02 | 1,226,673 | 5,029.36 | 0.17 | 495,480 | 2,031.47 | 0.22 |
| Gemcitabine[b] | 4,264 | 8.08 | 5,745,419 | 20.12 | 5,924,000 | 178,581 | 3,464.47 | 0.30 | 2,712,581 | 52,624.07 | 1.74 | 587,443 | 11,396.39 | 1.25 |
| Ipilimumab (Yervoy)[a] | 124 | 0.24 | 8,534 | 0.03 | 10,350 | 1,816 | 118,645.45 | 10.43 | 1,966 | 128,445.46 | 4.25 | 45 | 2,940.00 | 0.32 |
| Irinotecan[b] | 2,800 | 5.31 | 517,265 | 1.81 | 527,500 | 10,235 | 1,380.70 | 0.12 | 113,235 | 15,275.40 | 0.51 | 28,499 | 3,844.52 | 0.42 |
| Liposomal doxorubicin (Caelyx)[b] | 221 | 0.42 | 10,638 | 0.04 | 11,280 | 642 | 27,285.00 | 2.40 | 742 | 31,535.00 | 1.04 | 80 | 3,400.00 | 0.37 |
| NAL-irinotecan[b] | 53 | 0.10 | 4,743 | 0.02 | 5,547 | 804 | 12,340.47 | 1.08 | 1,019 | 15,640.47 | 0.52 | 151 | 2,317.67 | 0.25 |
| Nivolumab (Opdivo)[a] | 1,447 | 2.74 | 332,757 | 1.17 | 336,120 | 3,363 | 50,443.50 | 4.43 | 15,163 | 227,443.50 | 7.53 | 1,320 | 19,800.00 | 2.18 |
| Oxaliplatin[b] | 4,240 | 8.04 | 645,610 | 2.26 | 669,400 | 23,790 | 3,711.24 | 0.33 | 262,990 | 41,026.44 | 1.36 | 35,742 | 5,575.75 | 0.61 |
| Paclitaxel[b] | 6,125 | 11.61 | 757,288 | 2.65 | 791,700 | 34,412 | 3,510.00 | 0.31 | 1,089,212 | 111,099.60 | 3.68 | 41,626 | 4,245.85 | 0.47 |
| Paclitaxel-NAB (Abraxane)[b] | 1,341 | 2.54 | 204,662 | 0.72 | 215,000 | 10,338 | 46,521.00 | 4.09 | 56,338 | 253,521.00 | 8.39 | 2,267 | 10,201.50 | 1.12 |
| Panitumumab (Vectibix)[a] | 991 | 1.88 | 331,374 | 1.16 | 339,700 | 8,326 | 15,819.40 | 1.39 | 20,826 | 39,569.40 | 1.31 | 11,930 | 22,667.00 | 2.49 |
| Pembrolizumab (Keytruda)[a] | 2,397 | 4.54 | 442,843 | 1.55 | 444,600 | 1,757 | 86,093.00 | 7.56 | 1,857 | 90,993.00 | 3.01 | 7,020 | 343,980.00 | 37.80 |
| Pemetrexed (Alimta)[b] | 1,230 | 2.33 | 874,802 | 3.06 | 928,000 | 53,198 | 7,574.33 | 0.67 | 281,698 | 40,108.16 | 1.33 | 26,164 | 3,725.23 | 0.41 |

## Key benefits:

- *Positive environmental impact* –

  - Hazardous drug waste reduction of 31.4 kg $CO_2$e/year [NCCS] -> 157.0 kg $CO_2$e/year nationally

  - Pharmaceutical material waste reduction of 196.9 kg $CO_2$e/year [NCCS] -> 492.3 kg $CO_2$e/year nationally

- *Significant financial savings* of at least S$5.24 million/year to NCCS

- Facility in full *compliance to GMP/USP Standards*

- *Greater staff empowerment and work satisfaction*

**Achieving triple bottom lines** with no impact to clinical care and operation!

**Longevity of Solution**

Plan for Business-As-Usual (BAU) to be considered throughout life-cycle of proposed solution. Stakeholder engagement and communication, seamless transition, training and support, continuous monitoring and iterative improvement to deliver smart solution that is aligned with organizational goals.

## Year 1 — Initial Implementation and Validation

| Activities | Expected Outcomes |
| --- | --- |
| Develop and validate | Establish reliability |
| Evaluate compatibility and adoption on ground | Adoption in BAU operation |
| Pilot AI-calculator (SMART) in 2 identified drugs | Reduce drug wastage |
| Train pharmacy staff | Identification of key variables for ML and predictive performance |
| Set up monitoring and evaluation framework | Dashboard & real-time data visualization |
| Integrate AI-calculator in GMP lab for all drugs | Transition to AI-driven processes |

## Year 5 — Full Integration and Continuous Improvement

| Activities | Expected Outcomes |
| --- | --- |
| Enhancement of AI algorithms | Improve drug utilization and waste reduction |
| Longitudinal evaluation for long-term benefits | Data-driven insights |
| Comprehensive training programs | Competent and consistent deployment |
| Collaborate with stakeholders to set industry standards | Establish best practices and standards |

## Year 3 — Scaling, refinement, optimization

| Activities | Expected Outcomes |
| --- | --- |
| Expansion to other facilities | Compatibility with systems |
| Refinement and optimization, incorporating auto-feedback for continuous improvement | Standardized and optimized processes |
| Integration of Reinforcement Learning in SMART to balance optimality vs operational risk | Further enhanced benefits |
|  | Further reduce wastage and associated costs |
|  | Adaptability and scalability in real-time planning |

## 5+ and Beyond — Long-Term Vision and Expansion

| Activities | Expected Outcomes |
| --- | --- |
| Adoption beyond drug compounding | Set new standards |
| Continuous innovation | Forefront of technology |
| Global partnerships | Global collaboration |
| Predictive analytics for patient-specific dosing and inventory forecasting | AI-enhanced medication safety and healthcare delivery |
| Data security and privacy | Maintain patient trust and regulatory compliance |

# THANK YOU CHI, SIT & Coaches!

Algorithm-Driven Optimization for Sustainable Cytotoxic Drug Compounding in Healthcare

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