Note: This is Online Supplement Document 1 of Girdwood SJ, Compton T, Cassim N, et al. Optimising courier collection time improves patient access to HIV viral load testing in South Africa. Afr J Lab Med. 2022;11(1), a1725. https://doi.org/10.4102/ajlm.v11i1.1725

Supplementary Text 1

The optimized system enhanced the functioning of the current specimen routing network by incorporating additional factors that would improve specimen validity and be better aligned with patient-centred care. These included collecting specimens at PHC facilities as close to closing time (16:00) of the majority of PHC facilities as possible to allow for maximum access, prioritizing high volume facilities for more frequent courier collections, and better matching test demand at facilities to specimen collection frequency so that laboratory spikes and workflow were smoothed and specimens could be processed as quickly as possible. In order to match test demand at facilities to specimen collection frequency, facilities were categorized according to their testing volumes in order to determine the optimal frequency of specimen collection. The top 10% of facilities in terms of volume were provided four daily pick-ups; the next 15% of facilities in terms of volume received 3 daily pick-ups; the next 25% of facilities in terms of volume had two daily pick-ups. The bottom 50% of facilities, in terms of volume, was visited by the courier only once a day. Differentiation by province was also required with frequency cut-offs calculated for higher volume provinces and for the rest of the country in a separate group. Larger laboratories, in terms of volume and capacity, were assigned more routes and courier drivers. There were no capacity constraints on pick-ups as couriers utilize vehicles and therefore have adequate space for large specimen volumes. For couriers, we assumed that 10 minutes was required at the start of a route to collect consumables and results and 10 minutes at the end of the route to accommodate specimen delivery. For facilities, the time taken for the courier to collect the specimens from the health facility was dependent, broadly, on the type of facility (for example, 5 minutes for PHC facilities and 15 minutes for hospitals). Couriers for the different routes could start as early as 8:00 or as late as 15:00, but could only be on the road for a maximum of 9 hours per day. All healthcare facilities were required to be visited at least once prior to the standard 16:00 closing time. Facilities that only received once a day specimen pick-up could only have specimens collected after 12:00 at the earliest in order to provide sufficient time for patients to have their blood-drawn. Since couriers operated primarily after 8:00 and before 16:00 – i.e. out of peak traffic times, empiric traffic conditions were not considered. Facilities that receive specimen transport collection four times a day, may be visited by the courier at 9am, but would have a last courier visit scheduled between 15:00-16:00 to ensure that later patients were accommodated. Whilst every attempt was made to smooth specimen volumes arriving at laboratories by allowing for more frequent drop-offs prior to 16:00, no specific processing limitations of samples at laboratories were considered.

Supplementary Text 2

The vehicle routing problem algorithm solves the routing problem taking into account constraints (such as meeting servicing requirements that would improve specimen turnaround times) while using a heuristic process to minimize the objective function of reducing travel time and driving distance. The solver for the vehicle routing problem first generates an origin-destination matrix of shortest-path driving times between all facilities and all laboratories using a road network. This cost-matrix is then used to develop an initial solution by allocating facilities one at a time to the most appropriate route. This solution is then improved by resequencing the facilities allocated to each route, as well as reallocating some facilities to other routes, and exchanging some facilities between routes. The heuristic used in this process is based on ESRI's proprietary tabu search metaheuristic. Route zones around each laboratory were created to perform the function of speeding up the optimization as well as to ensure that facilities closest to a laboratory were picked up by the courier assigned to that laboratory and not some other courier associated with a laboratory that was further away. Route zones were created by first utilizing the ArcGIS Network Analyst Tool, the Location Allocation solver [16]. The location allocation algorithm uses a heuristic process to solve for a solution whereby facilities are allocated to their closest laboratory in terms of travel time. Route zones were then created around laboratories based on the facilities that were allocated to the laboratories via the location allocation process.