Strategic decision support for expanding a national breast milk banking network

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ABSTRACT
The South African Breastmilk Reserve (SABR) is a public benefit organisation that coordinates the equitable distribution of donor breast milk to neo-natal intensive care units (NICUs). The donated breast milk aids in combating infections in premature infant recipients, thereby decreasing premature infant mortality rates and saving hospitals substantial amounts in treatment costs annually.

Increased awareness of the benefits and availability of donated breast milk in NICUs has significantly increased the demand for the SABR's service, thus necessitating the rapid expansion and evolution of the SABR's breast milk banking network. An expansion strategy was developed to decentralise the network and reduce the operational load on the SABR head office, enabling sustainable national expansion.

Strategic decision-support models were developed to aid the planning of the network structure and site selections. These models inform decisions regarding the establishment of corner sites (interim collection and storage facilities).

SABR NETWORK EXPANSION PLAN
Unpasteurised donor breast milk (UDB) is donated by lactating mothers (screened and registered by the SABR) and collected and frozen at corners or milk banks. The corners subsequently send their UDB to the milk banks where all donor breast milk is pasteurised and stored. The pasteurised donor breast milk (PDB) is delivered on demand to an NICU in the SABR network to feed premature infants (registered with the SABR).

The SABR's current network is hampered by a lack of resources and an underdeveloped infrastructure. To improve its network structure, the flow of supplies and donated breast milk between the four main role players was standardised (as depicted in **Figure 1**).

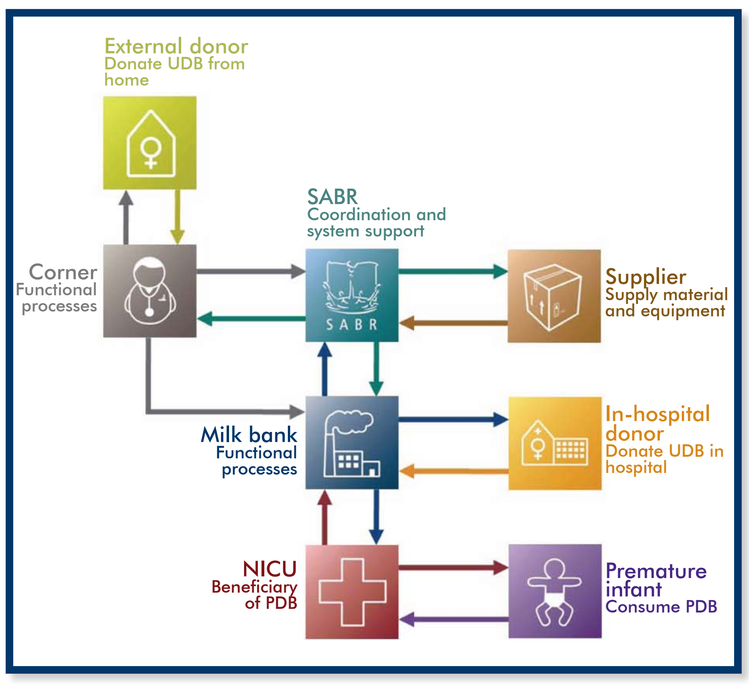


Figure 1: Proposed SABR network design

This will simplify the network dynamics significantly and enable the implementation of a uniform and duplicable transportation solution.

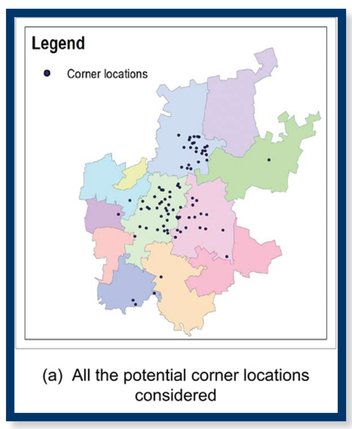
To realise its expansion goal of building a sustainable, breast milk banking infrastructure across the entire South Africa, the SABR is developing a franchise-like strategy in terms of which it remains the owner of the business concept while spreading the workload across a decentralised network of corners and in-hospital milk banks. The first step would be to establish SABR corners and assign these to existing milk banks in order to create resource capacity and stabilise the existing network. This model can then be duplicated across the provinces to extend the SABR's reach.

CORNER SITE LOCATION
A mathematical model was developed to determine the number of additional corners required and appropriate locations to place these corners in the SABR network's expansion. The model, based on the second Maximal Covering Location Problem with Spatial Objects (MCLP-SO2), presented by Alexandris and Giannikos (2010), attempts to maximise the total coverage of a specified number of facilities over varying demand areas.

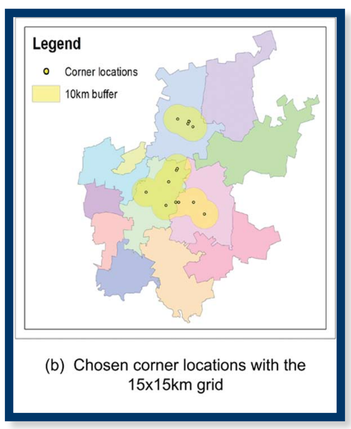
To illustrate its functionality, the MCLP model is applied to Gauteng to determine where new corners should be established to serve potential donors.

To transform the available data into the format required by the model, two pre-processing stages are performed. The first stage determines the coverage of donor clusters by potential corner locations and the second, the potential donor density of each cluster. Two donor cluster grid sizes are considered to investigate the model's sensitivity to grid size when all else is kept equal.

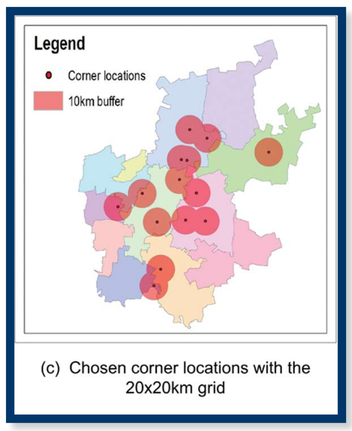
RESULTS
The model was solved using LINGO 10.0 optimisation software. A sensitivity analysis was performed for both grid sizes to determine the impact of the number of corners allocated on the potential benefit realised through increased coverage. The results show that increasing the number of corners increases the total benefit at a decreasing rate. The decision-maker must decide at which point the increase in total benefit no longer justifies the investment required to establish and maintain an additional corner. Furthermore, the results confirmed the model's inherent sensitivity to grid size. **Figure 2** maps the coverage obtained by both grid sizes when 14 corners are placed.



(a) All the potential corner locations considered



(b) Chosen corner locations with the 15x15km grid



(c) Chosen corner locations with the 20x20km grid

Figure 2: Comparison between potential and chosen locations in Gauteng for different grid sizes

The greater the size of the grid, the less benefit is to be gained in densely-populated municipalities such as the City of Johannesburg, the City of Tshwane and Ekurhuleni. The model thus places corners towards the less-densely populated periphery of the province to realise further benefit. In the case of Gauteng, smaller grid sizes ensure greater coverage in densely-populated areas, whereas the larger grid sizes tend to spread the coverage across the province. The decision-maker would have to decide which is more suitable.

WAY FORWARD
Before expanding the MCLP model to the rest of South Africa, data used to determine model parameters can be refined. Furthermore, refining the demographic assumptions made regarding potential breast milk donors would give a more accurate indication of potential donor density.

Subsequent network planning involves the selection of an optimal transportation alternative, strategic milk bank establishment, inventory planning and capacity planning. Once completed, a detailed implementation plan must be developed to inform the roll-out of the network.

Finally, the problem-solving approach followed throughout this research, and particularly the implementation of the MCLP, can be used to address similar network planning problems where supply must be gathered in small quantities from geographically dispersed donors. Two examples are the collection of donations during disaster relief efforts and food banking.

REFERENCES
1. Alexandris, G. and Giannikos, I. 2010. A new model for maximal coverage exploiting GIS capabilities. *European Journal of Operations Research*, 202: 328-338.
2. For more information see the full paper: Bean, W, Viljoen, N, Schoeman, C, Cooper, A.K. and Modise, M 2010. Strategic decision support for the expansion strategy of a national breast milk banking network. CSIR Conference. Pretoria.

The research approach can be used for similar network planning problems where supply must be gathered in small quantities from geographically dispersed donors