# Area association study applied to a medical group practice

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A BRIEF synopsis of the mechanics of setting up an Area Association Matrix is given in order to illustrate the essential new ground covered by our application of an area association study to a group practice surgery.

Area association is measured by the movement of 'mobiles' between 'components'. 'Mobiles' are defined as strictly anything that moves eg, doctor, nurse, trolley. 'Components' for a macro study, will be whole departments. For a micro study they will be rooms within a department or even furniture within a room. For our study we will consider the rooms of the group practice surgery individually, or where the relationship between several rooms is axiomatic, we may consider them in 'areas'. Examples of axiomatic relationships that could be used are:

1. That consulting rooms should be linked by interconnecting doors in a continuous line.
2. Reception, registration, records and the office can be taken as one component.
3. That patients' toilets should be placed adjacent to the patient waiting area.

These, and the other axioms, are testable by the methods of area association; however, to break the 'mobiles' down so finely would increase the complexity with only slight increases of rigour.

Once 'mobiles' and 'components' have been defined an estimate has to be made of the expected traffic movement by each 'mobile' between each 'component'. The mobiles must then be weighted, see below, and summed to obtain overall area association between each pair of 'components'.

The aggregated area association matrix is used by the architect to aid location of 'components' in a physical relationship mirroring their theoretical functional relationship. This depends on building in constraints on the other planning criteria or allowing the architect to juggle with the plan after generation—or a combination of the two. The process of plan generation may be done manually or automatically by a computer.

### Weighting of circulation figures

Having obtained figures by observation or prediction for individual class traffic movement between every component (or area) of the department and every other, these have to be combined to produce a single area activity matrix. To do this a weighted linear combination over all classes of traffic is taken.

The weights that have been assigned in the past have, however, varied greatly: M.o.H. 1966:

| | |
|---|---|
| Inpatient | 4 points |
| Outpatient day patients | 4 points |
| Outpatient with escort | 2 points |
| Medical staff | 4 points |
| Nursing staff | 3 points |

| | |
|---|---|
| Members of professions supplementary to medicine and other professional and technical staff | 3 points |
| Other staff | 1 point |
| All staff (meals, on or off duty etc.) | ⅛ point |
| Visitors | ⅛ point |
| Example: Nurse and attendant accompanying inpatient equals 8 points | |
| Ambulance and contractor's vehicles | 10 points |
| Bulk: Number of points shown are added for each single journey: | |
| Very bulky (requiring mechanical aid) | 2 points |
| Bulky (but can be carried by one person) | 1 point |
| Light (e.g. papers, briefcase) | No addition |

Whitehead and Eldars (1965):

'The number of journeys for each type of staff is modified by a factor representing the relative cost (salary plus overheads) of that type of staff in relation to the average, for example: '

| | *Total annual cost (salary and overheads)* £ *(assumed figures)* | *Factor* |
|---|---|---|
| Surgeon | 2400 | 1·6 |
| Average of all theatre staff | 1475 | 1·0 |
| Student nurse | 750 | 0·5 |

Cinar (1968):

| | |
|---|---|
| Medical staff | 12 points |
| Professional and technical staff | 6 points |
| Administrative staff | 4 points |
| Nursing staff | 3 points |
| Patients | 3 points |
| Domestic staff | 2 points |
| Visitors | 1 point |

'based on the average annual income of each staff group and, for patients and visitors a relative subjective evaluation.'

Taking a ratio of surgeon to student nurse as an example, it can be seen that these scales will give quite different results: 4 to 3, 1·6 to 0·5 (=9·6 to 3), and 12 to 3 respectively. Such a variation in weighting would give, for identical traffic flow matrices, different area association matrices and, correspondingly, different generated plans. Each scale has its own justifications, from a subjective assessment to a comparatively objective economic scaling.

An economic scaling is inappropriate to an area where patient movement is significant, such as an outpatient department. The relative cost of each patient is in effect indeterminable. Furtuermore, it can by no means be taken as axiomatic that 'total annual cost' is a measure of relative importance.

**The group practice study**

In the studies referred to above, traffic movement has been assessed from an existing environment. Some attempt has been made to allow for the architectural and managerial constraints; that is, how much the traffic movement is a function of existing facility provision, and the policies conditioned by them. It should not come as a surprise if these studies regenerate identical plans to those in which the measurements were taken, where conditions are very restrictive in nature.

For the group practice study we will be working from the operational policies. That is, we will be calculating the size of traffic movement in complete isolation from the architecture housing it. Such an appoarch is possible for a small problem, but for a larger one the calculations will increase geometrically as the number of elements involved.

*An example of the construction of a traffic movement matrix—an antenatal session patient.*

For the purposes of exposition we assume that the antenatal session adopts a very rigid form, that is:

Patient arrives from 'outside the building'.
Patient proceeds to 'waiting area'.
Patient proceeds to 'treatment area' (incorporating sub-waiting area).
Patient proceeds to 'consulting room'—one of three.
Patient returns to 'reception'.

either:

Patient returns to 'waiting area'.
Patient departs to 'outside the building'.

or:

Patient departs to 'outside the building'.

We assume that 20 per cent of patients return to the waiting area before finally leaving the building.

In order to construct the matrix we first list all possible starting points or destinations. They are for this example consulting room 1, consulting room 2, consulting room 3, treatment area, waiting area, reception and 'outside the building'. In theory this list should be extended to include all specific areas within the building plus 'outside the building'. This will need to be done when individual input/output matrices are summed in order to obtain an overall measure of association; however, at present, we will exclude this large number of zero entries.

The starting points and destinations are then listed vertically and horizontally, being starting points and destinations respectively, as the axis of a matrix.

(A) For patient moving from 'outside the building' to reception with probability 1 we insert 1 in the square corresponding to starting point—'outside the building' —and destination—'reception'.

(B) Similarly, we insert 1 in the square corresponding to starting point—'reception'— and destination—'waiting area'.

(C) Similarly, we insert 1 in the square corresponding to starting point—'waiting area'—and destination—'treatment area'.

(D) For entry into one of the three consulting rooms we insert 0·33 in the squares corresponding to starting point—'treatment area'—and destinations—'consulting room 1'. 'consulting room 2' and 'consulting room 3', respectively, as the patient will enter any of these three with probability 0·33.

(E) Similarly, we insert 0·33 in the squares corresponding to starting point—'consulting rooms 1, 2 and 3', respectively—and destination—'reception'.

(F) Patients now return to the waiting area with probability 0·2. We add 0·2 to the 1 inserted in the square, starting point—'reception'—destination—'waiting area'—, referred to in (B) above.

(G) With probability 0·2 they will leave the building from the waiting area. We therefore insert 0·2 in the square, starting point—'waiting area'— destination— 'outside the building'.

(H) With probability 0·8 they will leave the building from the reception. We therefore insert 0·8 in the square, starting point—'reception'—destination—'outside the building'.

(I) For all other squares we insert zero as there is no patient movement between their respective starting points and destinations.

If the matrix has been correctly constructed the row total of a given component as a starting point will always equal the column total of that same component as destination, as the former measures the expected number of times per visit that a patient starts

TABLE I

| *Starting point* | *Destination* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Consulting room* 1 | *Consulting room* 2 | *Consulting room* 3 | *Treatment area* | *Waiting area* | *Reception* | *Outside the building* | *Row total* |
| Consulting room 1.. | — | 0 | 0 | 0 | 0 | 0·33 | 0 | 0·33 |
| Consulting room 2.. | 0 | — | 0 | 0 | 0 | 0·33 | 0 | 0·33 |
| Consulting room 3.. | 0 | 0 | — | 0 | 0 | 0·33 | 0 | 0·33 |
| Treatment area .. | 0·33 | 0·33 | 0·33 | — | 0 | 0 | 0 | 1·00 |
| Waiting area .. | 0 | 0 | 0 | 1·00 | — | 0 | 0·20 | 1·20 |
| Reception .. .. | 0 | 0 | 0 | 0 | 1·20 | — | 0·80 | 2·00 |
| Outside the building | 0 | 0 | 0 | 0 | 0 | 1·00 | — | 1·00 |
| Column total .. | 0·33 | 0·33 | 0·33 | 1·00 | 1·20 | 2·00 | 1·00 | — |

from that component, and the latter measures the expected number of times per visit that a patient arrives at that component.

## Applications

When this matrix has been constructed we can multiply it throughout by the number of patients attending the session to get the total traffic movement throughout the session from starting points to destinations.

Similar matrices can be constructed for all 'mobiles' eg. doctors, nurses, trolleys, records, general-practice patients 'dressed', general-practice patients 'undressed', etc.

The matrices multiplied by their respective weights can then be added to obtain a total measure of 'area association'.

REFERENCES

Cinar, U. (1968). *Facilities planning: A systems analysis and simulation approach with particular reference to hospital design.* Ph.D. thesis, University of Lancaster.
Ministry of Health (1966). Hospital Building Bulletin No. 5.
Whitehead, B., and Eldars, M. S. (1965). *Building Science*, **1**, 127-139.

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**The American general-practitioner hospital.** A. J. M. Cavenagh, *British Medical Journal*, 1971, **2**, 516.

"In the USA and Canada full access of general practitioners to hospital beds and facilities is regarded as an essential privilege of their work. All hospital constitutions require a review of the credentials of staff applicants and continuing evaluation of their performance. Staff appointment carries administrative as well as clinical responsibilities and hospital work occupies a considerable proportion of the general practitioner's day. The disciplinary machinery for safeguarding standards is strict by comparison with British hospital practice.

This system produces an obvious excellence of clinical standards, postgraduate education, and communication between specialist and general practitioner and is attractive to the more able young British graduate. A pilot experiment of hospital staffing on North American lines in one of our new district general hospitals would be a worthwhile proposition".

(Author's summary).