Modelling medical resource allocation with multimedia data on hyper aged district in Taiwan

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Abstract: Facing the inevitable aging trend, Taiwan has implemented a long-term care program (LTC) to meet the demands of families with disabled seniors living at home. However, the medical resources currently provided by the local government, including physicians, nurses and physiotherapists that the shortage can reach 65%, 88% and 95%, has failed to catch up to the demands from the fast elderly growing population. The objective of this paper is to model the relationship of current disabled elderly at home and available medical resources by using linear programming. A multimedia data supported scenario and coordinated medical protocol have successfully provided the practical foundation of analysis in Taiwan. This study identifies the shortage of medical resources and provides optimal solution to shorten the difference under the cost concern is the number of (physician, nurse, and physiotherapists) to be (15, 27, and 22). This study excludes the local home care facilities for simplification purpose.

Keywords: disabled elderly; medical resource; multimedia data; model; demand-supply; Taiwan.


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1 Introduction

According to Coulmas (2007), three types of society exist based on the 65+ senior
population. The categories and their respective proportions are as follows: aging society
where 7%–14% of the population are 65 years or older; aged society: 14%–20% of the
population are 65 years or older; and hyper-aged society: 20% or more of the population
are 65 years or older.

Next to Japan, as a member of the hyper aged society, Taiwan has been one of the
fastest aging countries in the world. Council for Economic Planning and Development
(CEPD) of Taiwan has determined that Taiwan will emerge as an aged society by 2018
and then cross the 20% mark into a hyper aged society by 2026. The estimated time for
the population of seniors in Taiwan over 65 to increase from 10% to 20% only takes
19 years. This overtakes Japan’s 21 years, USA’s 63 years, Britain’s 74 years and
France’s 76 years. Moreover, the aging index of Taiwan also appears to be quite
pessimistic. According to the population policy paper (Ministry of Interior, 2013), the
aging index of Taiwan will reach 93.5% by 2015 and 129.2% by 2020. These forecasts
are indications of Taiwan’s demographic transition into a fast aging society where
challenges for the national economy, the local workforce and the senior medical care
system will surface.

A survey conducted by the Department of Health in 2010 shows that the rate of
disabled seniors (over 64) is 15.42%. As research shows, over 80% of seniors wish to live
with/near their family and receive in-family care. To accommodate the local customs and
wishes, the government has established health policies to meet these needs. Since 1998,
the government has promoted the long-term care programme (LCP) to cope with the
aging storm. The ten-year long programme was initiated in 2007 with the objective of providing medical services mentally and physically to seniors who passed the ADL screening at home or within their community.

Objective of this paper is to model the created scenario for nowadays’ medical allocation to the disabled elderly at home at a specific District on Taiwan. One of difficulties of this programme is data collection. Solution for that is to widen the source of data, which relies on a close look into the multimedia data. Finding an optimal solution for the medical resource allocation problem has been a continuous obstacle in meeting the main goals of the long-term care programme. Without specific rules or protocols to coordinate hospitals with their medical resources that are demanded by the disabled elderly (demanders), businesses interests can easily be the major factor to dominate this arena. The analytical view of this study is to quantify the supply-demand issue between the selected hospitals that can provide the medical service to the disabled elderly at home in the Meinong District of Kaohsiung city in Taiwan. A rule will be introduced in this model to regulate the allocation of medical resources. The rule can prioritise the available hospitals to distribute medical care for the satisfaction of the demanders. Linear programming (LP) is the mathematical method used to develop the model for this supply-demand problem.

2 Literature review

The ageing era has been emerging to the surface of Taiwan society so fast that studies and solutions for coping with the unique future scenario are a must for this country. The literatures for this study include the views in multimedia data, ageing trend, ageing health and care, government’s action, medical resource demanded, and LP allocation model in providing solutions for medical demand-supply issue, etc.

In light of big data technology, data collection for modelling is not a single rail from the structured data any more, instead, it is multi rails from unstructured data. Nowadays, conventional database has its limit for containing and processing the unprecedented speed of expanding data in variety forms. The healthcare refers to the data sets so large and complex that it is too huge and complicate to be easily managed by traditional software and/or hardware (Priyanka et al., 2014). Almost 80% of clinical data and clinical notes are unstructured documents, images and clinical or transcribed notes, such as post-op notes, diagnostic testing reports, patient discharge summaries, unstructured EMR/HER and medical images such as radiological images and X-ray images (Hsieh et al., 2013). For medical and healthcare analyses, unstructured data is the major source in terms of data collection. Big data analytics can perform predictive modelling to determine which patients are most likely to benefit from a care management plan. It is moving forward quickly in population health and quality measurement. Big Data offers a lot of benefits such as disease prevention, reduced medical errors and the right care at the right time and better medical outcomes (Wang and Alexander, 2015).

Several literature works have been selected for this study; including topics ranging from perspectives of the aging trend, aging health and care, government response, medical resource demanded, and the LP allocation model in providing solutions for this medical supply-demand issue. The aging issue is a global phenomenon. Taiwan has emerged as one of the fastest aging countries in the world according to researchers. Hwang (2008) indicated that the rate of the aging population in Taiwan is estimated to
increase 10% every 15–20 years, where the senior population in Taiwan will grow at a rate of 0.6% per year. The number of the seniors was 1.47 million in 1993, possibly increasing to 3.45 million by 2018 and 6.84 million by 2040 (Chen et al., 2014). Facts and data show evidence that the country will enter the aged society in less than five years. The hyper aged society, unsurprisingly, is only ten more years away. In fact, there are 23 districts in Taiwan that have already entered the hyper aged society ahead of the other areas. The highest senior ratio is at the Pingxi District in New Taipei City at 25.81%; and the lowest at the Dongshan District in Tainan City. This study focuses on one of these target areas: the Meinong District in Kaohsiung City (Chiou, 2011).

Other possible consequences of aging include health problems fatal to seniors. The most recent investigation includes statistics conducted by the Ministry of Health and Welfare (MOHW), showing the prevalence of chronic diseases frequently occurring in the senior group (as shown in Table 1).

The top one that causes death for elderly is chronic disease, according to MOHW. The top five of these chronic diseases are hypertension (46.7%), cataract (42.53%), heart disease (23.9%), gastric ulcer (21.17%) and arthritis or rheumatism (21.11%). The chronic diseases are the major cause of elderly disability.

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of chronic disease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>≥ 65</td>
<td>88.7%</td>
</tr>
<tr>
<td>≥ 75</td>
<td>90.9%</td>
</tr>
</tbody>
</table>

In order to recognize the differences among seniors, the population can be further divided into the following four groups: pre-old (aged 40–64 years), young-old (65–74), middle-old (75–84), and oldest-old (>84), according to Chen (2010). Based on statistics of MOHW, the prevalence of senior disability in Taiwan is the following: young-old is 7.29%, middle-old is 20.44% and oldest-old is 48.59%. The traditional way of living of seniors is to live with or live nearby the children so that their daily life can be well taken care of by their family. A survey (Statistical division of Ministry of Interior, 2009) shows that living with family in Taiwan has increased from 59.95% in 2005 to 68.46% in 2009. The willingness of living alone has decreased from 11.32% in 2005 to 6.85% in 2009. For home care of seniors, there are 16.8% of seniors with problems of autonomy. They mostly depend on their children (48.5%), spouse (20.2%) and nursing workers (16.6%) to take care of them.

The ten-year long care program (LTCP) was triggered in 2007 by the Central Government of Taiwan for initiating a policy in coping with the arrival of the ageing era with the responsive alternative in integrated perspective. The aim of this programme is to provide assistance for the seniors’ daily living activities such as home care, day care and adult placement. It also introduced new international models of senior care such as group home and unit care to Taiwan. The group home care has been the first responsive measure for the purpose of alleviation of family load of dementia patient with the improved quality of care by MOI, as suggested by Zhuang (2009). Same as the Western world and Japan, Taiwan also adopts the ageing in place policy. The objective of ten-year LTCP is to establish comprehensive long term care system, where it is able to insure the
disabled residence the capability to acquire the appropriate services, to enhance the ability in self-care independently, to improve the living quality, and to maintain their dignity and autonomy. The qualified residents who may receive the services include: seniors whose age is over 64, 55–64-year-old aboriginal, 50–64 year old disabled and seniors who lives alone with IADL compatible condition. The service includes care, home care, community and home rehabilitation, etc. (Ministry of Interior, 2007).

Home care is the issue in this study including at least three medical categories. Jia (2004) pointed out that in this ten-year LTCP, home care is the service provided by the government, where it is the model of delivering the medical care to the selected seniors in a way of a medical team. This specific medical team includes a physician, nurse, physiotherapist, medical social worker, occupational therapist, language therapist and dieticians (Jia, 2004).

How to deliver the specific medical care from the nearby hospitals to the demander’s home is also a serious consideration of medical resource allocation. The hospital cluster might be an alternative concept for Meinong District. Ploeg (2010) indicated that hospital-clusters are determined to divide the total demand in the region in such a way that patients are served as quick as possible and the demand of each hospital is proportional to its capacity. Hong Kong Hospital Authority organises hospital services in Kowloon East (KE) as a network of services by way of hospital cluster management. This is to ensure the delivery of a comprehensive scope of healthcare services to meet the needs of the population within the geographical region. The KE cluster covers Kwan Tong and part of Sai Kung (including Tseung Kwan O) with an effective population of 530276 (Health and Welfare Bureau, 2000).

In long-term care, Stone (2000) supposed that it is seen as a way to level the playing field between institutional care and home and community-based care. A growing number of policymakers also see it as a potential way to save money through more efficient allocation of resources and delivery of care. The medical resource allocation is one of the optimisation issues; hence using a right method is essential for seeking out the right solution. There are many available quantitative methods for medical resources analyses. However, according to statistics of Fleissner and Klementiev (1977), the most frequently used quantitative models in healthcare fields are 52 in total and grouped into five categories including 11 for each of simulation models and quantitative economic models, 24 of optimisation models (LP and Non-linear programming), six of Markov models and ten for others.

Earnshaw and Dennett (2003) supposed that the healthcare system is a gigantic and complex dynamic system where the scientific method is used. This includes macro quantitative economy, simulation and optimisation. The scientific method is used including macro quantitative economy, simulation and optimisation. Mathematical programming has become increasingly visible in facilitating the allocation of healthcare resources in the health services research sector. Studies (Propoi, 1978; Sartipi et al., 2011) showed that LP is one of primary methods for solving medical resource allocation. It can contain the extremely large number of variables and constraints. This is the reason why its important position in the decision field has been solidified. In fact, LP is a method for finding the best solution for a given mathematical model satisfying certain constraints by maximising or minimising an objective function, subject to linear equality and inequality constraints.
3 Scenario

The aging problem has continuously been a complex issue for Taiwan. MOHW shows that the latest Taiwan ageing ratio has reached 11.5% and predicts that it will be over 14% by 2017. According to the latest information of the Household Registration Office (2014), the targeted district Meinong has exceeded the 20% aging threshold and is rapidly approaching 21.7% (9077 out of 41668 total resident population). As shown from these statistics, Meinong is becoming one of the many hyper aged areas in Taiwan. The disabled senior population is estimated to be 1480 and distributed into three groups: young-old (344 residents), middle old (719) and oldest-old (417).

Medical resources that can provide Medical care include Cishan hospital, E-DA hospital and Chang Gung hospital.

If no rule exists to regulate the distribution of medical care from nearby hospitals to selected seniors living at home, then the profit oriented tendency of some hospitals would drive them to compete against each other for economic interests. A rule is embedded in the model and used to decide which hospitals can have a higher priority in providing its medical care to disabled seniors. It takes into account the distances in between hospitals and the Meinong District, with which the closer hospital may have higher priority for delivering the Medical care until the quota given by MOHW is used up. Then at this point, the next hospital can provide its service.

3.1 Assumptions

Hospital cluster: assuming the hospital of Cishan, E-DA and Chang Gung, represented by A, B, C are able to provide the Medical care to the Meinong District. Their distances in km are 4.4, 29.4 and 36.2, respectively. The coordination rule among hospitals is by distance: i.e., the hospital with the shorter distance can have higher priority to deliver the demanded medical care.

This action does not concern the other medical facilities, which are smaller in size. Two groups of disabled seniors at home may be determined to have a severe or less severe condition. The severe group is assumed to be over age 84 and the less severe group is from 65 to 84. The total number of seniors in each group, based on current information, is 1,063 and 417.

3.2 Concept of operations

Based on the policy of MOHW, only the disabled elderly who are approved by the authorised appraisal unit can acquire government funding support to the demanded medical care at home. However, the number of visits by the medical resources to these disabled elderly is confined by the following rules:

- The maximum number of cases for a physician to handle per day is eight, but the fee of each physician visit would be deducted when the number of cases is over four.
- There should be no more than 180 cases per month.
- Each case can only have one visit by a doctor, but without a time limit if the patient is in a critical condition.
• The maximum number of cases for a nurse to visit per month is one hundred. It is acceptable for a nurse to handle more than one hundred cases, but the visit fee would be at a 40% discount once it exceeds 100.

• The maximum number of a Physiotherapist (PT) visit per case each year is six, but no more than once a week.

• The visiting fee (NT dollar) per case for each medical category is 1035 for a physician, 1,370 for a nurse and 1,000 for a PT.

In an operation, the first concern is to set up the maximum medical capability in terms of full pay without discount, i.e., the physician can pay at most four visits per day, nurse can have no more than one hundred visits per month and the PT can have sixty visits per month. Time unit in analysis is on a two-month basis. Therefore the number of visits by a doctor/nurse/PT every two months is 176/200/120. It implies the cost of each medical category, C1, C2 and C3 to be 182,160, 260,000 and 120,000.

Table 2 Medical home care frequency demanded by homecare elderly

<table>
<thead>
<tr>
<th>Service</th>
<th>Serious</th>
<th>Less serious</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctor</td>
<td>n_{11}</td>
<td>n_{12}</td>
</tr>
<tr>
<td>Nurse</td>
<td>n_{21}</td>
<td>n_{22}</td>
</tr>
<tr>
<td>PT</td>
<td>n_{31}</td>
<td>n_{32}</td>
</tr>
</tbody>
</table>

In addition, the demand of the disabled elderly staying at home is the key factor in this supply-demand study. The disabled elderly are divided into two groups: serious or less serious condition. The serious group may receive more care from the hospital than the group of elderly with less serious conditions. Table 2 shows the medical demand from the disabled elderly, where n_{ij} stands for the number of specific medical resource demanded by these two groups of disabled elderly. The medical resource required by the serious group is two-times more than the less serious group.

As for the use of medical resources, the rule is to weigh the distance between hospitals and the Meinong District to determine which has the shorter distance, where it will be given the highest priority to deliver its medical service. Under the rule, the distance (km) of three hospitals, i.e., A, B, C, to Meinong District is 4.4, 29.4 and 36.2. Any hospital with the shortest distance will receive the heaviest weight. With normalised process, the weight of A, B, C is 0.5, 0.31 and 0.19.

4 Modelling

Conceptually, this is a supply-demand analysis by the linear programming model, where the objective is to maximise the distribution of medical resources to as many disabled elderly at home as possible. The model includes set, parameter, decision variables, objective function and restraints.

4.1 Definition

The set, parameter and decision variable are defined as the following:
Set

\( E \) elderly group
\( R \) medical resource categories: i.e., doctor, nurse and PT
\( H \) designated hospitals.

Parameter

\( L_{R,H} \) the maximum number of medical category provided by each hospital
\( N_{R,E} \) the number of medical care (per two months) demanded by the disabled elderly at home
\( M_{R,E} \) the number of visits by each R
\( C_R \) charge of medical care

Decision variable

\( X_{i,j} \) total number of medical resources which can be provided to the disabled elderly.

### Table 3

<table>
<thead>
<tr>
<th>Hospital category</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician</td>
<td>( X_{11} )</td>
<td>( X_{12} )</td>
<td>( X_{13} )</td>
</tr>
<tr>
<td>Nurse</td>
<td>( X_{21} )</td>
<td>( X_{22} )</td>
<td>( X_{23} )</td>
</tr>
<tr>
<td>PT</td>
<td>( X_{31} )</td>
<td>( X_{32} )</td>
<td>( X_{33} )</td>
</tr>
</tbody>
</table>

The decision variable used to represent medical resource is \( X \), which includes doctor, nurse and PT supplying by hospitals that are assigned to supply the targeted area. Definition of the variables is as Table 3.

#### 4.2 Objective function and constraints

The model’s objective is to maximise the resource utilisation. The purpose is to benefit as many disabled elderly at home as possible to see how much it will cost in the worst case scenario. Therefore, the objective function is expressed to sum up the cost of each medical category from each hospital already multiplied by the number of medical visits to the disabled elderly. The mathematical expression of objective is as follows,

\[
\text{Max} \sum_{i=1}^{g} \sum_{j=1}^{H} C_i X_{i,j} = 0
\] (1)

The constraints of the model are the relationship of demand and supply as follows:

Constraint 1 is to examine the resource that the medical care can supply to the elderly demand: each medical category in the hospital should be no more than the maximum number that the hospital can provide, i.e.,

\[
X_{r,h} \leq L_{r,h} \quad \forall e
\] (2)

Constraint 2: the total number of medical category for the disabled elderly should be no greater than their demand. The demand of each medical category is the number \( N_{R,E} \), E,
which is the sum product of the two groups of disabled elderly groups and their demand, divided by the total number of visits by the medical category. This can be expressed as

$$\sum_b X_{r,b} \leq \frac{N_{r,e}}{M_{r,e}} \quad \forall e$$  \hspace{1cm} (3)

Constraint 3 takes the rule of hospital prioritisation into consideration. The derived relationships by weight is as

$$0.63 X_{r,A} - X_{r,B} \leq 0$$

$$0.37 X_{r,A} - X_{r,C} \leq 0$$

$$0.59 X_{r,B} - X_{r,C} \leq 0 \quad \forall r \quad 0.63 X_{r,A} - X_{r,B} \leq 0$$

$$0.37 X_{r,A} - X_{r,C}$$

$$X_{r,h} \geq 0$$ \hspace{1cm} (5)

5 Analysis

The first concern is to check if the medical resources are distributed by the given rule. The rule defines the distance as the measurement of priority in delivering medical care to demanders. Before reaching the analysis of optimal solution to satisfy the demanders, it is necessary to look into the situation of medical supportability of hospitals.

5.1 Analysis of medical distribution under concept of hospital cluster

Let us denote the medical resource as the set \{X11, X12, X13, X21, X22, X23, X31, X32, X33\}. The first analysis is to consider the effectiveness of a hospital cluster. Assume the three hospitals are fully capable of delivering the home care medical support. This means that each of hospital’s staff is more than enough. The assumed number of physician/nurse/PT is 10/15/10.

Figure 1 The distributed medical resources from each hospital without clustered (see online version for colours)
The current situation is that this is not a hospital cluster. Among them, there is no coordinated relationship and any of them can deliver the medical service to the demander. This is very similar to the competition of the business market. In Figure 1, the numbers do not belong to a specific hospital. In other words, it can be randomly picked by any of the hospital as long as it is faster than the others. For example, 42% of nurse can be any hospital’s staff.

Under the hospital cluster, the coordination is defined by the hospital’s distance from the demanders. Under this rule, the result is in Figure 2, which shows the regular proportion among hospitals with the delivered medical resource.

Figure 2  The distributed medical resources from hospitals cluster (see online version for colours)

5.2 The current demand-supply analysis

Let the current situation be the base case with the set [1, 2, 1, 14, 4, 1, 8, 7, 2], representing the total medical resource the hospitals currently have available. The major work of medical resources focuses mostly on the hospital’s internal operation and with less attention to home care. As for what ratio of the hospital’s resource should be split out to support home care demand, the answer is still ambiguous (not yet defined) so far. Hence, let’s define the ratio of medical resources that can be assigned to the demand of home care, which is assumed to be 25%, 50% on the base of currently available medical resources. Table 4 shows three cases developed by the current information and case 3 is the base case. To have the medical personnel defined in fraction number is not reasonable at first glance but it becomes recognisable when we transform it into the number of visits to the disabled elderly living at home.

Table 4  Cases of available medical resources

<table>
<thead>
<tr>
<th>Hospital</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical category</td>
<td>Doctor</td>
<td>Nurse</td>
<td>PT</td>
</tr>
<tr>
<td>Case 1</td>
<td>0.25</td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td>Case 2</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Case 3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
Using the cases in Table 4 with the given medical resources, the result calculated by LP model is shown in Table 5.

**Table 5** Cases of available medical resources

<table>
<thead>
<tr>
<th>Case</th>
<th>$X_{11}$</th>
<th>$X_{12}$</th>
<th>$X_{13}$</th>
<th>$X_{21}$</th>
<th>$X_{22}$</th>
<th>$X_{23}$</th>
<th>$X_{31}$</th>
<th>$X_{32}$</th>
<th>$X_{33}$</th>
<th>Total cost (NTD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.25</td>
<td>3.36</td>
<td>2</td>
<td>0.5</td>
<td>1</td>
<td>1.75</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>1,986,918</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>6.72</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td>3,973,835</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6,592,400</td>
</tr>
</tbody>
</table>

**Figure 3** The current demand-supply situation (case 1) (see online version for colours)

In case 1, with 25% of the hospital’s medical resource for home care, the number of physician/nurse/PT is 6/3.25/1 which creates a shortage gap of $-9/-22.7/-21$, which is 60%, 88% and 95% shortage from elderly demand, as shown in Figure 3. The extremely scarce medical category is PT. Case 1 is the worst-case scenario for the disabled elderly living in the Meinong District.

The shortage ratio for these three cases is shown in Figure 4. If hospitals use 25% of their medical resource for supporting the elderly, the shortage of doctor/nurse/PT will be 60%/88%/95%. According to Figure 3, among medical categories, the shortage of physicians can be easily resolved. This implies that the denominator is very small. PTs are completely disregarded. Nurses seem to be better, but the shortage situation is still neighbouring to PT. In these three cases, nurses and PT have no chance to make up for satisfying the demand.

**Figure 4** The medical resource shortage in terms of demand (see online version for colours)
So far, the medical demand-supply is still unequal in these three assumed cases. The number of medical category is required to increase. But “how much medical resource is enough?” is a question in need of an answer. We need to find out the optimal solution for satisfying the current medical demand.

5.3 Analysis of finding the optimised solution

Let’s assume that case 4 is for increasing the medical support resource from hospitals with the objective of satisfying the demand. When the distributed medical personnel numbers match the demand, the number is the solution to this question. In case 3, the adjusted category is stressed on the nurse and PT. The available support medical personnel from each hospital, denoted as $(\text{doctor, nurse, PT})$ where $i$ represents the hospital name, in case 4 are $(10, 15, 10)_A, (10, 15, 10)_B, (10, 15, 10)_C$.

Using the LP model, the optimal solution that satisfies the disabled elderly home care demands $[X_{11}, X_{12}, X_{13}, X_{21}, X_{22}, X_{23}, X_{31}, X_{32}, X_{33}]$ equals to $[7.5, 4.7, 2.8, 13.5, 8.5, 5, 10, 7.6, 4.4]$ and costs at most $12,132,400$. The optimal solution for the medical resource devoted to Meinong is $(\text{physician, nurse, PT}) = (15, 27, 22)$.

If the budget from the government is enough for the disabled elderly home care case, then the left over will be $10,405,482.00, 8,418,565.00, 5,800,000.00$ with respect to the first three cases.

The number of medical resource for each hospital which can satisfy both hospital internal processes and home care needs can be calculated based on the optimal solution, as shown in Table 6. These numbers imply the current situation where the insufficient medical resource may hurdle the implementation of the ten-year LTC programme.

Table 6 Full hospital medical staff required in order to run both internal operation and the support of disabled elderly home care

<table>
<thead>
<tr>
<th>Hospital</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical category</td>
<td>Doctor</td>
<td>Nurse</td>
<td>PT</td>
</tr>
<tr>
<td>25%</td>
<td>8</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>50%</td>
<td>9</td>
<td>17</td>
<td>14</td>
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</tbody>
</table>

However, if there are extra medical resources can be released from the nearby medical facilities that might be a help in support of home care. However, if extra medical resources can be released from the nearby medical facilities, it might help in support of home care.

5.4 Discussion

The emergence of the fast aging society in Taiwan is a serious concern. The complex decision problems involved in medical care allocation and budgeting continue to trouble decision makers. By 2018, Taiwan will become a member of the aged society where seniors will have a higher probability to become physically or mentally disabled. This study utilises the LP model to analyse the medical demand-supply problem at one of the hyper aged districts in Taiwan. In conclusion, several hospitals have been identified around the target district to meet senior demands. If coordination and rules among hospitals are disregarded, then the medical resource provided by each hospital will be at
random. However, once we introduce the concept of the hospital cluster, medical resources can be managed according to the distances between hospitals and the Meinong District. The analysis shows that medical resources are distributed in percentage of (50%, 31%, 19%) with respect to hospitals (A, B, C). The analysis of the current medical allocation indicates the large shortage gap between nurses and PT. Even in case 3, the shortage ratio for nurse and PT still reached 50% and 82%. The denoted actual demand with optimal medical resource allocation can be \([X_{11}, X_{12}, X_{13}, X_{21}, X_{22}, X_{23}, X_{31}, X_{32}, X_{33}]\), which is equal to \([4.7, 2.8, 13.5, 8.5, 5, 10, 7.6, 4.4]\) with a maximum cost of $12,132,400 (NTD). The optimal solution is (physician, nurse, PT) = (15, 27, 22). However, this would increase the medical categories from the current \([1, 2, 1, 14, 4, 1, 8, 7, 2]\) to \([8, 16, 12, 6, 10, 10, 4, 6, 5]\) if the rate of medical support to disabled elderly home care is 25% of the hospital’s maximum medical resource.

In addition to the lack of medical resource delivered to seniors living at home, there are two major discoveries in this study. First, the supply-demand issue also existed in the other 22 areas in Taiwan. Some areas have hospitals or specific medical facilities around but some do not. Whether or not this medical insufficiency can be resolved is the key to the success of the LTC programme. Second of all, the ten year LTC programme is an alternative in coping with the aging trend, but realistically it seems to lack a resource management doctrine to help improve the management of medical resources. For example, regulate the hospitals with the hospital cluster concept. Third, the aging trend will not stop but will increase its speed. In conclusion, mathematical models can be utilised to provide the decision makers with insight of future medical supply-demand situations. This will allow the decision makers to assess the environment for other feasible alternatives and improved outcomes.

6 Conclusions

The aging trend will bring us huge challenges in every aspect of the world. The medical resources, in particular, would certainly be the most needed for elderly care at home. This study has pointed out the reality of medical shortage and lack of doctrine to coordinate the useful medical facilities in terms of elderly care at home. The LP method is used for modelling the medical vs. elderly care scenarios that the result can offer the decision maker a close look for the insight of medical demand and supply situations of elderly medical home care. This study has excluded disabled patients under the age of 65 who require the same care as disabled seniors. Furthermore, other hospitals and facilities of various sizes around the Meinong District, which have not been included in this paper, may also provide medical care. This may affect the precision of this analysis in some aspects. The contributions of this paper make is to develop a model based on the ageing trend, medical environment and current facts for a better understanding of the medical resource allocation issue in elderly care. The model has demonstrated that the problem can be resolved when incorporates multimedia data and has proven that the medical resource allocation decision making process can be validated by scientific analyses. There are more cities or Districts on Taiwan will confront the same ageing problem as indicated in this study but with very unique medical resources situation around. These can be the future study, which may discover more of the insights about ageing problems and the optimal way of medical care support.
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