Integrating Mental Health into a Primary Care System: A Hybrid Simulation Model

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Abstract Depression and anxiety appear to be the most frequently encountered psychiatric problems in primary care patients. It has been also reported that primary care physicians under-diagnose psychiatric illness in their patients. Although collaborative care has been shown to be a cost-effective strategy for treating mental disorders, to the best of our knowledge few attempts of modelling collaborative care interventions in primary care are known in literature. The main purpose of this paper is to propose a hybrid simulation approach to model the integration of the collaborative care for mental health into the primary care pathway in order to allow an accurate cost-effectiveness analysis. Quantitative analysis are reported exploiting different and independent input data sources in order to overcome the problem of the data appropriateness. The analysis demonstrates the capability of the collaborative care to reduce the usual general practitioner overcrowding and to be cost-effective when the psychological treatments have a success rate around the 50%.

Keywords: mental health, collaborative care pathway, cost effectiveness, discrete event, agent based, hybrid simulation.

1 Introduction

World Health Organization (WHO) estimates that as much as 24% of all patients contacting general health services suffer from well-defined psychological disorders and that another 10% have psychological problems which may not meet the criteria for a formal diagnosis of mental disorder, but diminish the quality of life and cause disability [13]. Nowadays such disorders are often diagnosed and treated in primary care settings adopting the *collaborative care* approach [9], in which specialised staff, i.e., psychologists, support the primary care practices. In Italy, collaborative care

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experiences are reported in [7] confirming also the association between medical-psychiatric co-morbidity and frequent utilisation of primary care resources, that is *frequent attenders* of a primary care service are usually affected by some mental disorders.

Cost-effectiveness analysis plays an important role in the economic evaluation of such interventions [14]. A critical review of model-based economic studies of depression argued hat little attention has been paid to issues around modelling studies with a focus on potential biases [1]. To the best of our knowledge, few attempts of modelling collaborative care interventions in primary care are known in literature [2]. None of these works analyse the impact of the frequent attenders to the usual general practitioner overcrowding. Further, the problem of the appropriateness of data sources used to estimate input parameters is discussed in [12].

The main purpose of this paper is to propose a hybrid simulation approach to model the integration of the collaborative care for mental health into the primary care pathway in order to allow an accurate cost-effectiveness analysis. The hybridisation of different methodologies is a way to deal with challenging problem arising in health care analysis [4]. In this problem, the challenge is to model the behaviour of the population pertaining the general practitioner, which differs from their frequency of attendance, and the patient flow within the collaborative care pathway. To this end, the proposed hybrid approach exploits the Agent Based Simulation (ABS) and the Discrete Event Simulation (DES) methodologies to model the population behaviour and the collaborative care pathway, respectively. Instead of using our own data, we use different and independent data sources in order to overcome the problem of their appropriateness.

2 The mental care pathway: a case study

In the last years, several trials has been carried out in Piedmont Region[1]. Among them, we selected the trial carried out at the local health unit ASLTO3 in Turin. The trial consists in offering mental care for 10 hours per week within a general practitioner office. Further, phone and home support is also provided. Such a trial defines a *mental primary care pathway*, that is the the step-by-step patient flow within the collaborative care pathway.

The mental primary care pathway implemented at the ASLTO3 is depicted in Figure 1. The general practitioner (GP) meets a patient that could suffer from a mental disorder. If the GP recognises a mental disorder and the patient is willing to accept psychological care, the collaborative care process starts with a counselling between the GP and the psychologist in order to define the level (*low*, *medium* or *high*) of the mental disorder. In the case of indecision, the patient can follow the usual primary care pathway or can accept a consultation with the psychologist before starting

[1] Regione Piemonte, *Indirizzi e raccomandazioni per l'implementazione dell'assistenza psicologica nelle cure primarie nella rete sanitaria territoriale del Piemonte*, Scheda P.A.S. 2012 - n. 4.1.7, 2013.

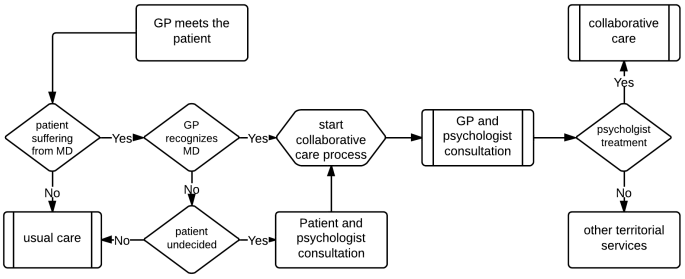

Fig. 1 Collaborative care pathway at the ASLTO3.

the collaborative care process. Each treatment ends up with a success or a failure. A *success* consists in a remission of the patient' symptoms with a decrease in the number of visits to the GP: in our case study, the success of a treatment is measured adopting the CORE-OM self-evaluation scale [6], which evaluates the improvement of the patient's life quality. Note that only patients with a low or medium level of mental disorder – in accordance with ICD-10 criteria – are treated, while high level patients will be in charge of the specialised service.

3 The hybrid model

We report the proposed hybrid (DES and ABS) simulation model to represent the integration of the collaborative care for mental health into the primary care pathway in order to allow an accurate cost-effectiveness analysis.

Modelling the mental primary care pathway with DES. Inspired by the case study discussed in Section 2, we propose a model for the mental primary care pathway. The DES model is a straightforward implementation of the pathway depicted in Figure 1. As mentioned in the introduction, one of the main characteristics of our approach is to different and independent data sources to animate our model. From this perspective, the main interesting part of the DES model is its parametrization. According to the daily schedule of an Italian GP (the studio is open at least 4 hours per day) and to the national statistics [11], the number of daily patients is 20 (5 per hour) and, if the patient requires a consultation, it lasts around 30 minutes. The inter-arrival time of a patient is modelled using an exponential distribution while the duration is a triangular in the $[20,40]$ interval. Among all the patient entering to the GP, the percentage of the those suffering from a mental disorder is 24% as reported in [13].

According to the case study trial, the psychologist can work with no more than 3 patients per week for no more than 10 hours per week. The treatment duration for low and medium level patients is, on average, 3 (in the case of the treatment

is a simple consultation) and 8 hours (in the case of the treatment is a psychotherapy). The percentage of high level patients is 7.3% while the remaining have low or medium level. Among them, the 42.1% follows a psychotherapy while the remaining the simple consultation. Finally, the success rate of a treatment is set to 80%, as in the case study.

Modelling the population behaviour with ABS. Different studies [7] confirm that primary care frequent attenders are usually affected by mental disorders. Thus we should pay a particular attention when modelling the population pertaining a GP since we have to take into account their frequency. As in [3], we would exploit the ABS methodology to describe a behavioural model representing the different patient status. Figure 2 describes the proposed behavioural model of a patient.

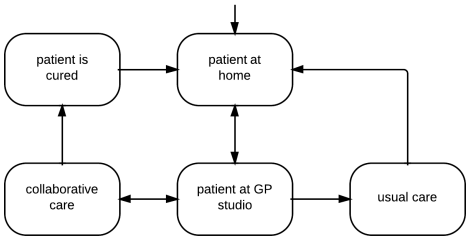

Fig. 2 Behavioural model: state-chart representing all the possible status of a patient.

The patient usually stays at home, that is he/she is not going to the GP; when needed, the patient goes to the GP to have a consultancy; after the consultancy, two possible paths are available: the former is the usual care pathway while the latter is the collaborative care one. On the usual care pathway will flow all the patients not affected by a mental disorder and those affected but not recognised and/or not accepting the collaborative care pathway. Starting the collaborative care pathway, after a while a patient could be cured (depending on the treatment success) becoming a *routine attender*. We recall that the remission of the patient' symptoms implies also a decrease in the number of visits to the GP.

In our ABS model, a population of patients pertaining a given GP is modelled by generating a number of agents, each one following the behavioural model depicted in Figure 2. The behavioural model of each agent is characterised by a specialised setting determining, for instance, if that patient is a routine or a frequent attenders. Such settings are defined according to the parameters reported in Table 1, which also report the source of each value.

Table 1 Values of the parameters determining the patient population (MD = mental disorder).

Description	Value	Source	Description	Value	Source
Number of frequent attenders (FA)	15.0%	[11]	Number of high level among FAs	11.8%	[8]
Number of routine attenders (RA)	85.0%	[11]	Number of high level among RAs	1.85%	[8]
Number of FAs suffering from MD	30.2%	[8]	Number of accesses to the GP by FA	$>$ 12 per year	[11]
Number of RAs suffering from MD	10.8%	[8]	Number of accesses to the GP by RA	$<$ 5 per year	[11]

The hybrid model. The proposed hybrid model is composed of a population of n patients ($n \in [1300, 1350]$ [11]) pertaining of a given GP. Each patient is modelled by an agent following the behavioural model depicted in Figure 2. When the agent have a state transition from "patient at home" to "patient at GP studio", the hybrid model generates an item to represent the patient flowing within the usual care or collaborative care pathways following the DES model. If the patient will follow the usual care pathway then a state transition will be enabled from "patient at GP studio" to "usual care"; otherwise, the model will enable a state transition from "patient at GP studio" to "collaborative care". When the patient finishes his/her "collaborative care" a state transition to "patient is cured" is enabled. When this item exits from the DES, the agent/patient makes a state transition from the "usual care" or "patient is cured" to the "patient at home".

4 Quantitative Analysis

We provide an overview of the results that can be obtained using the proposed hybrid model. We recall that the reported results are obtained running the model using different and independent data sources in order to overcome the problem of the data sources appropriateness. The hybrid model is implemented using AnyLogic [5]. The running time required for each experiment is negligible.

Validation. Although the validation of a simulation model usually requires a quite complex analysis, in our case it is quite easy due to the simplicity of our DES model. Our validation experiment consists in a repeated test (30 times) to evaluate the output and the outcome of the model. The validation experiment is performed by forcing that the number of patients entering in the collaborative care process is around the number of patients actually participated in the trial, that is 41. Further, the time horizon is the same of the trial, that is two years.

The output, at the end of the time horizon, complies with the trial, that is the number of low/medium patients treated with a consultation is 17, those treated with a psychotherapy is 11 and those taken in charge by the specialised territorial service is 3. The remaining 10 patients have not yet finished their pathway. The outcome of the collaborative care is measured in term of successes and failures of the treatments. Again, the results at the end of the time horizon complies with the trial: the consultation has 14 successes and 3 failures while the psychotherapy 9 and 2.

On the basis of these considerations, the comparison is satisfactory with respect to our objective, that is the validation of the logical correctness of the proposed hybrid model.

Tuning of the parameters. The tuning of the model consists in determining a suitable parametrization of the resources involved in the DES model: actually, the validation of the DES model has been performed on the case study which involved a limited number of resources, that is 1 psychologists operating for 10 hours per week (from Monday to Friday). We refer to this case as scenario S_1.

We introduce a further scenario, say S_2, in which 2 psychologists operate for 20 hours per week for a grand total of 40 hours which seems closer to the real needs of a mental primary care pathway. Both scenarios shares the same settings about service times within the DES model while the patient population has been generated according to the Table 1. We recall that the success rate of the treatments is estimated at the 80% as in the case study reported in Section 2.

Table 2 Tuning the hybrid model: results on the scenario S_1 and S_2.

Description	S_1	S_2
Population		
total number of patients	1328	1329
number of FAs with mental disorder	61	62
number of RAs with mental disorder	123	123
number of patients with low/medium mental disorder	174	176
Accesses to the GP		
number of accesses by FAs	375	380
number of accesses by RAs	1879	1895
number of saved accesses by FAs	154	640
Mental Primary Care Pathway		
number of patients treated	30	120
number of patients waiting for their treatment	141	53

Table 2 reports the results regarding the two scenario S_1 and S_2. The table is divided in three main sections: population, accesses to the GP and mental primary care pathway. Regarding the first section, it is worth noting that the composition of the population complies with the values reported in Table 1. Regarding the number of accesses, the number of saved accesses is an estimate computed with respect to the instant in which a frequent attender with mental disorder is cured becoming a routine attender. This estimate is higher in scenario S_2 due to the higher number of resources available. Anyway, it shows that the mental primary care pathway can effectively reduce the GP overcrowding. The third and last section shows the number of patient treated and those waiting for a treatment. Note that the increase of the number of patient treated in scenario S_2 is proportional to the increased number of hours offered by the psychologists.

Cost-effectiveness analysis In this section, we would provide an analysis in order to evaluate the cost effectiveness of the integration of the collaborative care for mental health into the primary care pathway, In this analysis, we will consider a third scenario, say S_3, which is the same of S_2 but the time horizon is extended from 2 to 5 years. This scenario is introduced to evaluate the economic sustainability in the medium/long term.

While it is quite easy to identify the cost of a psychologist treatment within the mental primary care pathway, the cost of the usual care pathway is more difficult since it is concerned with different way of treating a not recognised mental disorder. Considering the Italian NHS, to the best of our knowledge the most accurate estimation is reported in [11] in which a range of yearly costs per patient is reported: the usual care costs from 2100 to 2500 € while the mental primary care costs from

900 to 1100 €. This difference is due to the fact that the latter is essentially the hourly cost of a psychologist multiplied the number of hours of the treatment while the former should considers not only the cost of the GP but also of the examinations usually prescribed by the GP himself.

Table 3 reports a cost comparison between the two pathways, that is the mental primary care and the usual care pathways. The results show the cost effectiveness of the mental primary care pathway proving also the capability of reducing the cost of the whole NHS system. Further, results for scenario S_3 show the sustainability of the system in the medium/long term.

Table 3 Cost analysis: ranges of results (in Euro) on the 3 scenarios.

Description	S_1	S_2	S_3
Estimated costs (€)			
Mental Primary Care Pathway overall cost	26850 – 32816	107880 – 131853	148350 – 181316
Usual Care Pathways overall cost	43470 – 51750	179340 – 213500	264030 – 314416
variations	16860 – 18707	71460 – 81527	115010 – 133170

The treatment success rate is the crucial parameter: actually, a lower success rate can determine the cost-ineffectiveness of the mental care pathway. To provide more insights to our analysis, we repeated our cost analysis varying the success rate of the psychologist treatment so far set to the 80%. We report the results only for the scenario S_2 since those for S_3 are almost the same.

Table 4 Cost analysis: ranges of results (in Euro) varying the success rate on scenario S_2.

Description	80%	40%	50%
Estimated costs			
Mental Primary Care Pathway overall cost	107880 – 131853	108270 – 132330	108000 – 132000
Usual Care Pathways overall cost	179340 – 213500	88130 – 104917	108920 – 129667
variations	71460 – 81527	-20140 – -27413	900 – -2334

Table 4 reports the results of the analysis. It is worth noting that the mental primary care pathway become cost effective as soon as the treatment success rate is around the 50%. Note that the same result is reported in the well-known Depression Report [10] providing also a further ex-post model validation.

5 Conclusions

We proposed a hybrid simulation model to evaluate the integration of collaborative care for mental health into a primary care system. In line with the current trends, the hybrid approach allows us to face properly the challenging modelling issues, that is

how to model and integrate the behaviour of the population pertaining the general practitioner and the patient flow within the collaborative care pathway overcoming the the main weakness of the previous analysis, that is the appropriateness of data sources. To the best of our knowledge, this is the first attempt in the health care management literature. The quantitative analysis demonstrates the capability of the collaborative care to reduce the usual GP overcrowding and to be cost-effective when the psychological treatments have a success rate around the 50%, as reported in [10]. The proposed model could be extended to evaluate (i) the net social benefits in terms of quality-adjusted life years, and (ii) several resource sharing strategies and their impact on the GPs overcrowding.

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