AHP AND RISK MANAGEMENT: A CASE STUDY FOR ASSESSING RISK FACTORS FOR FALLS IN COMMUNITY-DWELLING OLDER PATIENTS

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ABSTRACT

Falls occur frequently among older people and represent the most common cause of injury-related morbidity and mortality in later life. Preventing falls is an important way to reduce injuries, hospitalizations and injury-related morbidity and mortality among older people. The research literature has identified hundreds of risk factors for falls among elderly people. Prioritizing risk factors for falls is useful for designing effective and efficacious prevention programs.

The aim of this study was to use the Analytic Hierarchy Process to develop a hierarchy of risk factors for falls based on the knowledge and experience of experts working in this field.

We designed a web portal to submit electronic questionnaires in order to reach the highest number of respondents quickly and to reduce errors in responding. We contacted the person responsible for the Falls sections of four scientific societies. Finally, we propose a correction method to modify respondents' relative importance on the base of coherence of their responses, in order not to exclude experts neither resubmit twice the same questionnaire.

Keywords: AHP, Falls in Elderly, Web Service.

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1 Introduction

The research literature has identified hundreds of risk factors for falls among elderly people (Gillespie 2000), and it is well established that falls risk in old age is complex and multi-factorial. However, there are no reports of the views of health care professionals specialized in falls on the relative importance of these risk factors.

The aim of this study therefore was to use the Analytic Hierarchy Process (AHP) (Saaty, 1980), to develop a hierarchy of risk factors for falls based on the knowledge and experience of experts working in this field.

It is important to understand views of different professionals in this area, and how experts balance risk of falls. In fact, theoretical information and guidance, which exist and have been widely proved, is not yet fully entered in daily patient care. One of the reasons could be that medical professional do not follow professional evidenced based guidance they do not "believe in". This leads us to investigate scientifically care operators opinions and emphasize differences from evidence-based results.

In order to reach the wider number of expert respondents, we designed and realized a web based system to submit questionnaires and analyze results. The system is described further in this paper.

1.1 Scenario of falls in elderly

Falls occur frequently among older people and represent the most common cause of injury-related morbidity and mortality in later life (King and Tinetti, 1995; Nevitt and Cummings,1989). The annual incidence of falls among older people is estimated between 15% and 35%-40% in community-dwelling people aged 65 and over. The consequences of falls range from psychological aspects (Parry and Steen, 1982), physical injuries (Lord and Sherrington, 2007) and hospitalization, to death (Laurence 2006). Falls can also negatively affect wellbeing, mobility, autonomy and overall quality of life.

Preventing falls is therefore an important way to reduce injuries, hospitalizations and injury-related morbidity and mortality among older people. Identifying and prioritizing risk factors for falls is useful for designing effective and efficacious prevention programs.

2 Method

The method used to prioritize the risk factors is an application of the Analytic Hierarchy Process (AHP), implemented via the World Wide Web. We adopted AHP as analytic decision-making method to understand, in order to prevent, risk of falls, which is complex, multifactorial and multidimensional problems (Saaty, 2005). The main idea is that it is more reliable to assess relative importance of risk factors, comparing pairs of them using a natural language scale, than judging their absolute importance.

2.1 Hierarchy of risk factors

Using the research literature, we identified a range of risk factors for falls, and designed a hierarchy by grouping them into categories (i.e., general and clinical) and sub categories (i.e., physical, mental, socio-environmental, physical health, drugs and medical conditions) of risk factors. We then developed and piloted a questionnaire to ask experts to compare pairs of categories, sub-categories, and individual risk factors within each sub-category. This hierarchy of comparisons aimed to prioritize risk factors and their categories. This Hierarchy approach allows the construction of a consistent step-by-step framework of decision-making, following the assessed paradigm known as *divite et impera*.

2.2 Questionnaires

In order to reach the highest possible number of respondents, we designed an electronic questionnaire, located at: http://hosting.vaisuinternet.it/, and a web service (Pecchia et al., 2008), to analyze the answers

remotely. For each pair of category of risk factors (R_i, R_j) the respondent was asked the following question: "in your opinion is R_i, compared to R_j: much more important, moderately more important, equally important, moderately less important, much less important. We posed similar questions to compare the categories of risk factors. In accordance with the natural scale of Saaty, we gave a numerical value to each judgment:

Table 1: Saaty Fundamental Scale.

Judgments	**Score**
much more important	5
moderately more important	3
equally important	1
moderately less important	-3
much less important	-5

Piloting the questionnaire, as described below, we decided to use 5 ("much more important") as maximum magnitude, since the first respondents seems to be disoriented from a wider scale. The point was that respondents reported that there were not factors, which dominate others more than "much more". The negative signs were used in order to synthesize in one question, which factor was dominant and how much. The negative numbers (a_{ij}) where then transformed, via a web service, in its positive reciprocal (a_{ij}^*), using the following transformation:

$$a_{ij}^* = -\frac{1}{a_{ij}} \qquad (2)$$

In fact, if R_i is "moderately less important" than R_j ($a_{ij} = -5$), then R_j should be much more important R_i ($a_{ji} = 5$), therefore the reciprocity of judgments matrix implies $a_{ij} = 1/5$. Moreover, respondents were permitted to use intermediate judgments (as in Figure 4), scored with even numbers (positive and negative), to express further insights, or if they could not decide between adjacent categories.

2.3 Judgments matrix

With the scores provided by the respondents for each category, a Web Service automatically evaluated a matrix (A) which had as the generic element (a_{ij}), the score coming from the comparison of R_i with R_j, while the element a_{ji} is the reciprocal of a_{ij} and the diagonal elements a_{ii} are equal to one. These proprieties represent the assumption that: if R_i is 3 times more important than R_j, then R_j should be 1/3 of R_i; R_i is equally important to it self.

It has been proved that, if the judgments are consistent (see next section for details), the normalized eigenvector of this matrix expresses the relative importance of each risk factor. This step was iterated for each category of risk factor. Finally, the same algorithm allows the relative importance of each category of risk factors to be assessed.

2.4 Consistency

In addition, from each matrix it is possible to estimate the consistency of the responses from each respondent, in order to test the *transitivity of judgments*, which is a fundamental hypothesis in each Hierarchy method. Obviously, a perfect coherence is difficult to achieve in complex judgment. Nevertheless, every time it is important to assess the degree of coherence of respondents, because a high level of inconsistency by individuals, can lead to a low level of *consistency* in the decision framework.

2.5 Strategy of error management

The hypothesis of global consistency of the model has to be tested, as in any other medical-scientific study based on mathematical/statistical methods. The AHP allows measuring the consistency (Saaty, 2005b, Saaty 1996) of any questionnaire responses by posing some redundant questions. For instance, to compare the three elements, A, B and C, the respondent is asked to perform the comparison of B with C (a_{BC}), which could be deduced by the pair comparisons A-B (a_{AB}) and A-C (a_{AC}). Then, the answer is compared with the judgment deduced and the difference represents the degree of inconsistency. If the two judgments are not perfectly consistent, there will be an error, which can be quantified as:

$$error_{BC} = a_{BC} - \frac{a_{AC}}{a_{AB}}$$

This error is zero if the judgments are perfectly consistent. Mathematically, the coherence of each response is measured with the error generalized defined as:

$$(1) \qquad error_{ij} = a_{ij} - a_{1j} * a_{i1}$$

Nevertheless, inconsistency is often due to distractions or loss of interest by the respondent and not to a global incoherence of the respondent's opinion. This is particularly true in a web based response system. For this reason, when responses are inconsistent, the questionnaire should be re-submitted to the respondent. This strategy is possible when the respondent can meet to discuss and settle inconsistencies in responses; however, this was not possible in all the phases of this study, with exception of piloting.

So far, we chose a threshold error and excluded respondents with a higher level of inconsistence. Then we used the inverse of consistence index to correct respondent relative importance before pooling data. We pointed out this method borrowing polling techniques in meta-analysis (Sutton et alt., 2000)

Finally, we modeled the *error* has as an accuracy-error, which is zero when the framework is completely consistent. An increasing error means a progressive loss of consistency individually and overall. This error is then propagated until the final index of relative importance affecting its precision is estimated. For instance, if a respondent judges A>B and B>C, s/he should judge A>>C. A direct answer of A>C or A>>>C, is not perfectly consistent, but it is certainly more consistent than A<C or A=C. The AHP defines a method to assess the degree of inconsistency. We adopted this technique to correct relative importance of respondents in order to poll final data as described above. Moreover, we used this error to define the interval of precision of each relative weigh.

2.6 Assessment of relative importance

As stated, after excluding inconsistent respondents and comparing the risk factors, we calculated the Relative Importance index (RI) within each sub-category (termed "intra-categorical weighs" or "Local Weights", LW). From the pair-wise comparisons of categories and sub-categories, we estimated the relative importance of each of them ("inter-categorical weights", ICW). Finally, by using both weights, we estimated the global relative importance of each risk factor ("global weights", GW). All those weights are affected by the error described above, and so far have to be reported with an imprecision of less than or equal to the threshold-error.

2.7 The web system

To reach the wider number of respondents, we designed and developed a web portal for questionnaires submission, and a web services for data processing and results analysis and pooling.

The whole system, follows the so-called "Three Tier Layer" architecture, and is organized in three areas: "Client Area" that acts as presentation tier, "Server Area" as business tier and data tier and the "Web Service Area" as pure business tier level. Each one of these areas is independent from the others and can

operate with other Informative Systems using common standards. In synthesis, the "Client Area" aims to collect data and present elaborations results; the "Server Area" to manage, to store and to retrieve data; the "Web Service Area" to process raw data and transform it from the judgment matrix to relative importance weights. Moreover, in this area, a web service analyzes data regarding respondent experience and, following the system described above, executes the data pooling.

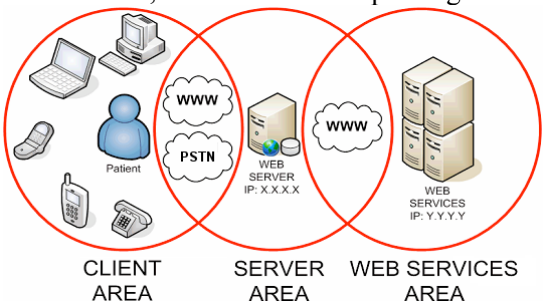

Figure 1 The three "Areas" of the system: Client, Server and Web Services.

2.8 Data pooling

We pooled the data from the responses of any respondent weighted (W_r) basing on his/her experience, taking into account the following information about respondents: years since specialization, level of education, area of work. Table 2 presents the assigned weights of each level of feature. We report the mean and the Standard Deviation, to represent the spread of opinion across the sample of respondents. We then evaluated, for each category and each risk factor, the global weights (GW), which represent its relative importance. In case of not fully coherence, it is suggested to resubmit the same questionnaire to the respondents. Since we chose not to resubmit twice the same questionnaire, we first pooled all the results coming from respondents, which show fully coherence with a CR < 0.1. Then, in order to include the wider number of respondents, we introduced the correction methods, detailed in the next paragraph.

Table 2: Weighting assigned according to time since qualifying, highest educational qualification and area of work.

Feature	Weight	Relative Importance Weight
Years since qualification		
>15	0.61	15.3
6-15	0.25	6.3
3-6	0.10	2.5
1-2	0.04	1.0
Education		
Ph.D., MD, or equivalent	0.59	11.8
MSc or equivalent	0.25	5.0
BCS or equivalent	0.11	2.2
Profess Qualification	0.05	1.0
Area of Work		
Falls health services/studies	0.57	4.1
Elderly health services/studies	0.29	2.1
Other	0.14	1.0

2.8.1 Correction of respondents relative importance in case of not perfect coherence

As introduced above, we submitted the questionnaires to respondents, which are not in the same place. So far, we could not ask them to resolute divergent judgments. Moreover, we preferred not to exclude respondents neither to ask them to answer again. For this reasons we introduced a correction method in order to accept also respondents with a CR over the suggested threshold of 0.1. Then we used the exceeding ΔCR to correct the relative importance weight (W_r^*) of respondents as described with the formula (3).

$$(3) \quad \begin{cases} \Delta CR = CR - 0.1 & \\ W_r^* = W_r & if \quad \Delta CR \leq 0 \\ W_r^* = W_r * (1 - 10 * \Delta CR) & if \quad \Delta CR \in]0;0.1] \end{cases}$$

3 Results and Discussion

3.1 Hierarchy of Risk Factors

We individuated from the literature a set of 39 risk factors, which was reduced to 35 during the pilot study, based on feedback from the respondents. We organized these 35 factors into categories and sub-categories in developing the hierarchy. In the research literature, various studies have investigated risk factors for falls. However, few authors have proposed classifications to categorize risk factors (Panel of Falls Prevention, 2001) and none is based on the opinion of experts from different specializations.

The guidelines of the AGS/BGS/AAOS suggested classifying these at least into ***intrinsic***, ***extrinsic*** and ***environmental factors***. The UK-based NHS Centre for Reviews and Dissemination (http://www.york.ac.uk/inst/crd/) classified the potential risk factors of falls into five major categories: environmental; medication; medical conditions and changes associated with ageing, nutrition, and lack of exercise (Preventing falls, 1996). Rubenstein et al. (Rubenstein et alt., 1996; Rubenstein, 2006, Masud et alt., 2001) proposed a classification of causes of falls in elderly people, supported by 12 studies, as shown in Table 3. While this classification is interesting, it presents a clustering of risk factors and a percentage range, which do not allow such information to be used to define a detailed model for predicting falls.

Table 3. Summary of causes of falls in 12 studies that evaluated elderly persons after a fall and specified a 'most likely' cause. (From Rubenstein et al.)

Most likely cause of fall	**Mean [a] (%)**	**Range [b] (%)**
Accident/environment-related	31	1–53
Gait/balance disorders or weakness	17	4–39
Dizziness/vertigo	13	0–30
Drop attacks	9	0–52
Confusion	5	0–14
Postural hypotension	3	0–24
Visual disorder	2	0–5
Syncope	0.3	0–3
Other specified causes [c]	15	2–39
Unknown	5	0–21

[a] Mean percentage calculated from the 3,628 falls in the 12 studies.
[b] Ranges indicate the percentage reported in each of the 12 studies.
[c] This category includes arthritis, acute illness, drugs, alcohol, pain, epilepsy and falling from bed.

In respect of these studies, following the Hierarchy approach, we classified the main risk factors reported in the literature into two main categories (Figure 3): "***general risk factors***" and "***clinical risk factors***".

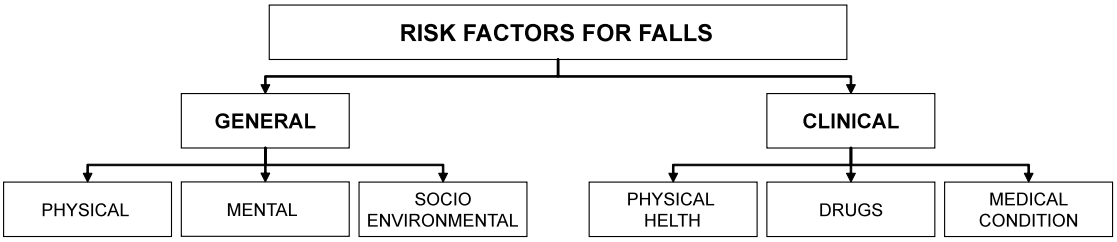

Figure 2. Risk Factors' Hierarchy.

We considered general risk factors (Table 4) to be those that are not usually pathologic, i.e., which could concern any older person (including healthy older people), and which include environmental factors. This category includes three sub-categories of risk factors: *physical,* which includes those factors associated with an individual's stature and capacity; *mental*, which includes psychological factors associated with aging; *socio-environmental*, which includes factors related to the living arrangements of the person.

Table 4: General risk factors organized according to each sub-category.

Physical	**Mental**	**Socio-environmental**
high bmi	fear of falls	need help toileting
loss of weight	depression	low family support
poor joint flexibility	early stage dementia	low social engagement
low walking speed	loss of balance	low social service support
low muscular strength	low cognitive perception	need to use stairs/steps in home
low level of physical activity	perceived risk of falls	
	poor self rated health	

Clinical risk factors concern frail older people with various health problems (Table 5). This group includes three sub-categories called: *physical health factors*, which are, in different proportions present in healthy, as well as in pathological subjects; *drugs*, which embrace different medications; *medical conditions*, which include typical diseases of elderly people.

Table 5: Clinical risk factors organized according to each sub-category.

Physical health	**Drugs**	**Medical condition**
Visual problems	anti-depressives	postural hypotension
continence problems	anti-psychotics	nervous system disease
dizziness	beta-blockers	musculoskeletal disease
mobility aids	diuretics	Stroke
sleeping problems	sedatives	polypharmacy
		previous syncope
		taking any prescribed drugs

3.2 Questionnaires

As described above we organized the 35 risk factors into 2 categories and six subcategories. So far, we needed seven questionnaires of which six to assess local weights and one to assess category weights. We first used paper questionnaire in order to pilot it in-lab. Then we designed and realized a web page for each questionnaire to rich the highest number of respondents as described in the next paragraphs. The time to answer all the questions was almost double in the paper version. In fact, the mean time to complete the questionnaires was about 20 (±12) minutes for the respondents involved in technical scientific piloting, and 27(±14) minutes for the enrolled experts, which responded to all the questions after the piloting. Instead, the paper version, used only during the piloting, was completed in the mean

time of about 56(±16) minutes. Moreover, we counted in the paper version different kind of errors due perhaps to inexperience of respondent with such a peculiar layout, even though we granted wide explanation before each questionnaire, also with full examples (Figure 3).

Example

For example, if you think that in public health initiatives to reduce the s pread of HIV/AIDS, "promoting safe sex" is much more important than "having a needle bank" then mark the two boxes as follows:

promoting safe sex > = < *having a needle bank* 1 2 3 4 5 6 7 8 9

Instead if you think that "having a needle ban k" is between much more important and very much more important than "promoting safe sex" then please mark the two boxes as follows:

promoting safe sex > = < *having a needle bank* 1 2 3 4 5 6 7 8 9

Or, if you think that "having a needle bank" is Equally important to "promoting safe sex" then please mark the two boxes as follows:

promoting safe sex > = < *having a needle bank* 1 2 3 4 5 6 7 8 9

Figure 3. Example used during the piloting of the questionnaire in the paper-version.

In the electronic version no compilation-errors were possible due to the use of "combobox" objects (Figure 4), which allows using only natural scale instead of "sign and magnitude" to express pair judgments.

Figure 4 combobox used to demonstrate responses.

Also, we decided to randomize the order of pair comparisons to avoid automatisms in respondents, which could be tired due to such a long questionnaire. Moreover, we pay attention to have the same number of recurrences of each risk factor to the left and to the right of the comparison. We did it in order to reduce possible biases due to the tendency of inattentive respondents to correlate the importance of factors to the usual reading versus. Figure 5 and Figure 6 show the same questionnaire implemented on the paper version and in the electronic one.

***Section 3.2,* Clinical risk factors. Questionnaire 4: Physical Health risk factors**

Indicate which you think is the more important physical health risk factor for falls in older people.

visual problems	> = <	ear problems	1	2	3	4	5	6	7	8	9
continence problems	> = <	physical aids	1	2	3	4	5	6	7	8	9
physical aids	> = <	ear problems	1	2	3	4	5	6	7	8	9
sleeping problems	> = <	visual problems	1	2	3	4	5	6	7	8	9
ear problems	> = <	continence problems	1	2	3	4	5	6	7	8	9
visual problems	> = <	physical aids	1	2	3	4	5	6	7	8	9
physical aids	> = <	sleeping problems	1	2	3	4	5	6	7	8	9
sleeping problems	> = <	continence problems	1	2	3	4	5	6	7	8	9
ear problems	> = <	sleeping problems	1	2	3	4	5	6	7	8	9
continence problems	> = <	visual problems	1	2	3	4	5	6	7	8	9

Figure 5. one of the questionnaires from paper version. We randomized the order of pair wise comparisons and dispose it to have each factor two times left and two times on right of comparisons.

Figure 6. The same questionnaire shown in Figure 5, implemented in the electronic version.

Finally, the elaboration of responses performed via web services, as described further in the paper, allows reducing post-elaboration time and so far risk of error due also to manual transcription, especially with such a number of respondents.

3.3 Respondents and study execution

A technical pilot study was first performed in our labs, involving 32 respondents to define the editorial model trying to minimize the risk of errors. A scientific pilot study involving a group of nine experts, with different backgrounds and specializations, then completed the questionnaires independently. All nine respondents had working experience in the field of falls in the care of elderly people. Four **physicians** (comprising a ***consultant geriatrician*** with 11 years' experience, a ***general practitioners/family doctors*** with 28 years' experience, a MD who specialized as a ***gerontologist*** with 28 years' experience, and a ***geriatrician*** with 22), four **physiotherapists** (with 10, 12, 13 and 13 years' experience) and one **professor of physiotherapy** comprised the group. On the basis of their responses, the proposed classification was modified slightly and the selected risk factor reduced from 39 to 35. After obtained the ethical approval from University of Sheffield, an invitation letter, containing also a link to the reviewed questionnaire, was sent by email via the moderator of the email distribution list for the British Geriatrics Society (BGS), the AGILA Chartered Society of Physiotherapy working with older people and to the program of work focused in falls preventions called "Preventing Falls Program". The link contained a "get" variable to track the association of the respondent, so we know that from the 196 final respondents, who visited the web questionnaire, 163 where experts from those groups. Of those, 68 (41.7%) completed the questionnaires. Table 6 gives details about all respondent background.

Table 6: Number of respondents during piloting and final consistent respondents.

	Technical Piloting	**Scientific Piloting**	**Final respondent experts**
University	31	1	2
Physicians	1	4	12
Physiotherapists	-	4	44
Nurses	-	-	10
Tot.	32	9	68

From the "final respondent experts" and the "scientific piloting group", the 29% works in "falls services", the 42% works with "general elderly care service". Also the 16% declared a MSc and the 8% a Ph.D. or MC. The mean number of "years since qualification" was 18.9 (±10.56).

Of all the 68 final respondents, 10 (14.7%) completed the questionnaire ***consistently*** (Table 6) with a CR <0.1, as suggested by Saaty, in all subcategories. Moreover 24 (35.3%) exceeded the recommended threshold level in just one questionnaire on 7, with a CR in mean of 0.14(±0.03). As explained above, since we preferred not to exclude respondents neither to ask them to answer again, we used a correction method for the respondents which answered with a $CR \in (0.1;0.2)$. We increased the CR level, using the ΔCR to correct the relative importance of responders as described with the formula (3). So far, we included also respondents with a CR≤0.2, which are 37(54.5%) with such a CR in all the 7 questionnaires, and 62 (91.2%) if we admit the ones which reach such augmented CR in 6 questionnaires on the 7 submitted.

3.4 The web system

The web system aims to reach the widest number of respondents. We designed all the system using .NET web technologies, particularly to implement easily controls to avoid compilation errors. For instance the system does not allow going next the following questionnaire if all the questions of the previous have not been answered.

Figure 7 synthesize the architecture of the implemented platform and the logic of the system, which follows the three tier level model.

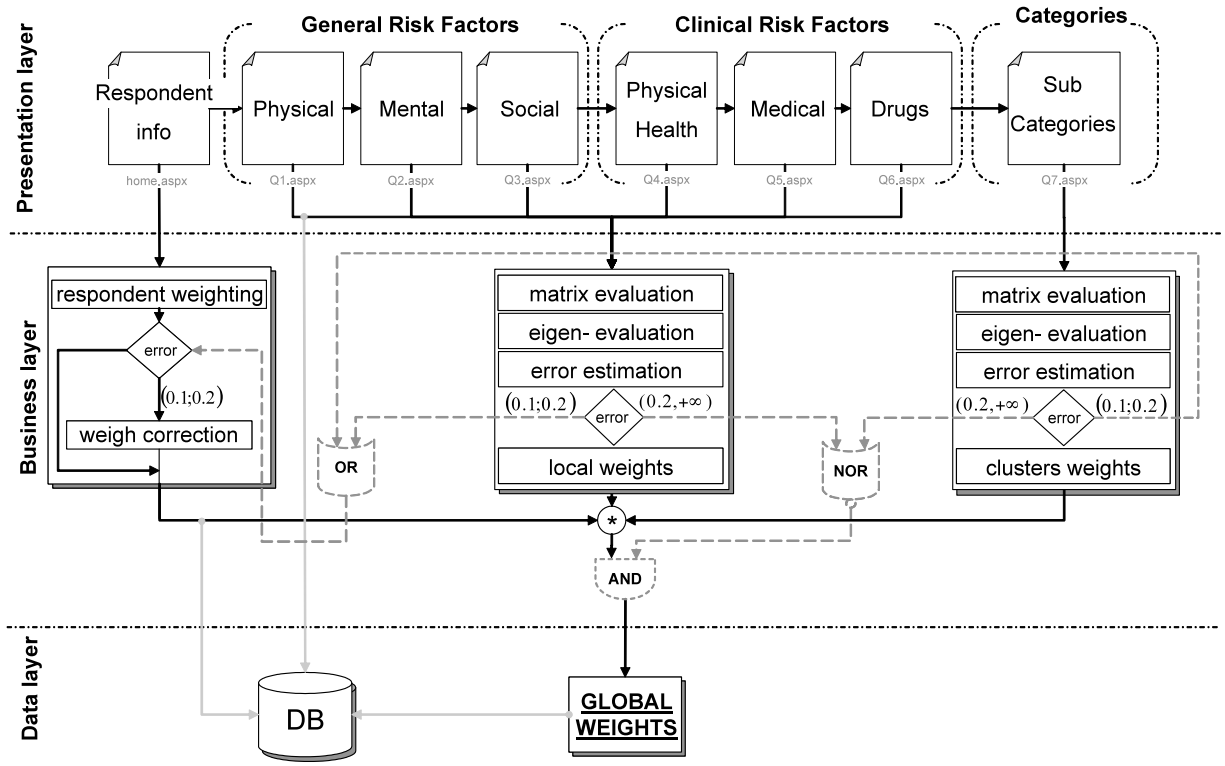

Figure 7. Web system architecture and service logic.

3.5 Data Pooling

As discussed in the previous paragraphs, to pool results obtained from different experts it is important to weight each feature of the respondent. The adopted weighting system is summarized in Table 2. We assumed that the three considered features are equally important.

3.5.1 Fully coherent respondents

Using those weights the scores attribute by each respondent to each subcategory of Risk Factor, was pooled. The results of this pooling are presented in Table 7.

Table 7: global weights of sub-categories of Risk Factors

Sub Category	**Category**	**Mean** (%)	**Range** (%)	**GW** (%)	**RIW**
Mental	General	19.1	12-26	20.2	**1.5**
Physical	General	19.1	12-26	20.2	**1.5**
Physical Health	Clinical	16.4	11-22	15.5	**1.2**
Drugs	Clinical	16.2	10-23	15.3	**1.2**
Socio-environmental	General	15.6	10-21	15.6	**1.2**
Medical	Clinical	13.7	7-21	13.1	**1.0**

GW: Global Weight; **RIW**: Relative Importance Weight.

For all the sub categories a score (the "inter-categorical weights") was evaluated for each respondent and then mediated (Mean). These values have been weighted with relative importance of each respondent to obtain the Global Weight (GW) of each sub-category. This score was normalized and expressed as a percentage in Table 7. The range gives an indication of the data dispersion, which reflects the differences in the opinions of the respondents. These differences are also due to the general nature of the questions asked in this study; for example, if the questions were more focused on a particular case (e.g. a patient suffering from specific condition, or a more specific definition of the fall), it is possible that the respondents' opinions may have been less diverse. In fact, different categories of community-dwelling older people could have relatively different risk factors for falls. Finally the Relative Importance Weight (RIW) is estimated by dividing the GW for the minimum, which is "clinical-medical subcategories" in this case. The RIW, reflect how much, in the opinion of respondents, each sub category is more important in respect to the less important one.

Table 8 presents the relative importance of the individual risk factors. We evaluated the same synthetic parameters described above. RIW expresses the relative importance of each Risk Factor normalized to the least important factor ("low social services support").

Table 8: Risk Factors.

Risk Factor	Category	Sub-Category	Mean (%)	Range (%)	GW (%)	RIW
low muscular strength	general	physical	1.77	1.00-2.54	1.89	5.9
low level of physical activity	general	physical	1.61	0.93-2.29	1.72	5.3
loss of balance	general	mental	1.53	0.70-2.37	1.62	5.0
need help toileting	general	socio-environmental	1.56	0.67-2.46	1.59	4.9
fear of falls	general	mental	1.34	0.55-2.13	1.40	4.3
low walking speed	general	physical	1.03	0.27-1.78	1.13	3.5
poor joint flexibility	general	physical	1.12	0.75-1.49	1.12	3.5
use of sedatives	clinical	drugs	1.11	0.57-1.66	1.10	3.4
use of antipsychotics	clinical	drugs	1.07	0.58-1.57	1.08	3.3
early stage dementia	general	mental	0.96	0.38-1.53	1.07	3.3
use of antidepressives	clinical	drugs	1.07	0.50-1.64	1.06	3.3
low cognitive perception	general	mental	0.97	0.62-1.33	1.03	3.2
dizziness	clinical	health physical	1.09	0.57-1.61	1.01	3.1
perceived risk of falls	general	mental	0.96	0.32-1.60	1.01	3.1
visual problems	clinical	health physical	1.06	0.59-1.53	1.00	3.1
stroke	clinical	medical	1.00	0.50-1.50	1.00	3.1
continence problems	clinical	health physical	1.02	0.56-1.49	0.97	3.0
use of mobility aids	clinical	health physical	0.98	0.58-1.39	0.95	2.9
nervous system disease	clinical	medical	0.93	0.43-1.43	0.94	2.9
depression	general	mental	0.83	0.47-1.18	0.87	2.7
previous syncope	clinical	medical	0.89	0.11-1.68	0.86	2.7
poor self rated health	general	mental	0.81	0.21-1.42	0.85	2.6
postural hypotension	clinical	medical	0.93	0.25-1.60	0.84	2.6
poly-pharmacy	clinical	medical	0.88	0.20-1.56	0.82	2.6
need to use stairs/steps in home	general	socio-environmental	0.81	0.50-1.12	0.82	2.5
use of diuretics	clinical	drugs	0.97	0.15-1.79	0.79	2.4
low social engagement	general	socio-environmental	0.73	0.18-1.27	0.77	2.4
sleeping problems	clinical	health physical	0.67	0.26-1.08	0.63	2.0
musculoskeletal disease	clinical	medical	0.66	0.24-1.09	0.62	1.9
low social service support	general	socio-environmental	0.65	0.22-1.08	0.61	1.9
low family support	general	socio-environmental	0.57	0.26-0.89	0.54	1.7
loss of weight	general	physical	0.46	0.26-0.65	0.49	1.5
betablockers	clinical	drugs	0.53	0.18-0.88	0.48	1.5
high bmi	general	physical	0.37	0.23-0.51	0.38	1.2
taking any prescribed drugs	clinical	medical	0.34	0.09-0.59	0.32	1.0

The range shown in the previous tables is too high to identify clearly the classification between each one of the risk factors. This may be also due to the high number of risk factors. Nonetheless, it is clearly discernible that there is consensus that some factors are widely more important than other.

3.5.2 Correction of respondents relative importance in case of not perfect coherence

By applying the correction introduced above, we could include 42 respondents obtaining the following results for the sub categories.

Table 10 global weights of sub-categories of Risk Factors

Sub Category	**Category**	**Mean** (%)	**Range** (%)	**GW** (%)	**RIW**
Mental	General	22.6	13-32	23.1	**1.8**
Physical	General	18.0	11-25	18.3	**1.4**
Physical Health	Clinical	18.0	11-26	16.7	**1.3**
Drugs	Clinical	16.1	11-22	15.5	**1.2**
Medical	Clinical	13.2	7-20	13.6	**1.1**
Socio-environmental	General	12.0	7-17	12.8	**1.0**

Comparing this table with the Table 7 it results that the global classification does not change much, with the exception of the last two sub-categories. Anyway such differences could be due to wide ranges which reflect divergence in the opinion of respondents. Divergences between respondents' opinion is anyway a primary outcome of the study, which have to be considered.

Table 11. First 15 risk factors with error corrections.

Risk Factor	**Category**	**Sub-Category**	**Mean (%)**	**Range (%)**	**GW (%)**	**RIW**
loss of balance	general	mental	1.90	0.61-3.20	2.10	5.9
fear of falls	general	mental	1.79	0.82-2.76	1.75	4.9
low muscular strength	general	physical	1.65	0.86-2.44	1.68	4.7
low level of physical activity	general	physical	1.33	0.68-1.98	1.40	3.9
need help toileting	general	socio-environmental	1.17	0.53-1.82	1.28	3.6
Sedatives	clinical	drugs	1.32	0.84-1.80	1.23	3.4
perceived risk of falls	general	mental	1.22	0.56-1.88	1.19	3.3
dizziness	clinical	health physical	1.31	0.43-2.20	1.16	3.2
visual problems	clinical	health physical	1.31	0.56-2.06	1.15	3.2
antipsychotics	clinical	drugs	1.06	0.61-1.51	1.09	3.0
poor joint flexibility	general	physical	1.14	0.44-1.83	1.06	3.0
early stage dementia	general	mental	1.07	0.24-1.90	1.06	3.0
low cognitive perception	general	mental	0.99	0.55-1.43	1.02	2.8
low walking speed	general	physical	0.94	0.30-1.58	1.00	2.8
postural hypotension	clinical	medical	0.98	0.39-1.57	0.99	2.8

In addition, the results on Risk factors prioritization do not change substantially. The first 15 Risk Factors are the same in both groups of respondents. The first five are almost in the same order. Nonetheless, the difference between RIWs of consecutive factors is minor, or comparable, to the range. This leads to conclude that a detailed classification of all the factors could be not fully statistically significant, due to divergences in opinion of respondents.

Moreover, both group of respondent agree to classify drugs "high bmi" and "Taking any prescribed drugs" as the last two prior factors for falls in elderly, and the last ten factors are the same.

Table 12. Last nine risk factors with error correction.

Risk Factor	Category	Sub-Category	Mean (%)	Range (%)	GW (%)	RIW
sleeping problems	clinical	health physical	0.68	0.19-1.16	0.65	1.8
musculoskeletal disease	clinical	medical	0.62	0.26-0.99	0.64	1.8
low social engagement	general	socio-environmental	0.56	0.14-0.98	0.61	1.7
betablockers	clinical	drugs	0.61	0.14-1.09	0.57	1.6
loss of weight	general	physical	0.52	0.20-0.83	0.51	1.4
low social service support	general	socio-environmental	0.43	0.09-0.76	0.48	1.3
low family support	general	socio-environmental	0.47	0.15-0.79	0.47	1.3
high bmi	general	physical	0.44	0.10-0.78	0.45	1.3
taking any prescribed drugs	clinical	medical	0.33	0.08-0.58	0.36	1.0

4 Conclusion

In the study described in this paper, we investigate how AHP could contribute in assessing priority of Risk of Falls in elderly home-dwelling. Our conclusions are that AHP can contribute in assessing hierarchy of risk factor. Moreover, it is useful to investigate relatively broad spread of opinion across respondents. This could be due to different background and we are investigating this hypothesis, trying to quantify differences. The high number of risk factor individuated, the low difference between consecutive RIWs and the relative high spread between respondents opinion do not allow pointing out a statistically significant punctual-scale of risk factors. Nonetheless, this study allows clearly individuate the factors considered more relevant for falls as the less relevant ones. Further studies could be done asking to prioritize the most important. Nonetheless, the difference of opinion between respondents is by it self a primary outcome of this study. Further investigation should try to assess its reasons.

Nonetheless, the final hierarchy provides further insights into clinicians' perceptions of risk factors for falls. The hierarchy presented is based on expert knowledge of the causes of falls, while other classification are based on survey data and data from hospital admissions, the latter of which could introduce bias by considering only those falls which require direct hospital care. Risk is the combination of the probability of an event and the subsequent effects on the individual. While the prevention of falls requires an approach that considers all potential risk factors, these results suggest the factors that, in the opinion of clinicians, are the most important factors to be targeted for falls prevention program.

The implementation of the web system to submit blind questionnaires, allows reaching a wide number of respondents. Also the time to complete the questionnaire was almost the half when the electronic version was used. Finally no errors of compilation were registered and users which answered to both version reported that the electronic version was more user-friendly and easy to approach then the paper one.

The method suggested to correct the weights attribute to each respondent on the base of its coherence (CR), allows to include a wider number of respondent without losing significance in the final scale.

Next version of the web system will support a control of coherence, which in real time will suggest and underline respondent's inconsistencies. This control will ask him to review the comparison which present the highest error, by comparing the ratio of the two corresponded elements of the eigenvectors to the correspondent value of the judgments matrix, as suggested by Saaty.

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