

Use of the Analytic Hierarchy Process (AHP) for examining healthcare professionals' assessments of the relative importance of risk factors for falls in community-dwelling older people.

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Summary

Background: a gap exists between evidence-based medicine and clinical-practice. Every day, healthcare professionals (HCPs) combine empirical evidence and subjective experience in order to maximise the effectiveness of interventions. Consequently, it is important to understand how HCPs interpret the research evidence and apply it in everyday practice. We focused on the prevention of falls, a common cause of injury-related morbidity and mortality in later life, for which there is a wide range of known risk factors.

Objectives: to use the Analytic Hierarchy Process (AHP) to investigate the opinions of HCPs in prioritizing risk factors for preventing falls.

Methods: we used the AHP to develop a hierarchy of risk factors for falls based on the knowledge and experience of experts. We submitted electronic questionnaires via the web, in order to reach a wider number of respondents. With a web service, we pooled the results and weighted the coherence and the experience of respondents.

Results: Overall, 232 respondents participated in the study: 32 in the technical pilot study, nine in the scientific pilot study and 191 respondents in the main study. We identified a hierarchy of 35 risk factors, organized in two categories and six sub-categories.

Conclusions: The hierarchy of risk factors provides further insights into clinicians' perceptions of risk factors for falls. This hierarchy helps understand the relative importance that clinicians place on risk factors for falls in older people and why evidence-based guidelines are not always followed. This information may be helpful in improving intervention programmes and in understanding how clinicians prioritise multiple risk factors in individual patients. The AHP method allows the opinions of HCPs to be investigated, giving appropriate weight to their coherence, background and experience.

Keywords: falls, falls prevention, older people, community-dwelling, AHP.

1. Introduction:

Evidence-based care advocates that clinical decisions for preventing, treating and managing diseases in individual patients are made with reference to the best available empirical research evidence [1, 2]. A gap exists between the systematic use of evidence-based medicine and everyday clinical practice. Health care professionals (HCPs) need to incorporate knowledge continually from distinct areas into medical decision-making [3]. To maximise the effectiveness of healthcare interventions, HCPs have to combine empirical evidence with their own experience; this formulates their approach to using specific interventions. They combine this approach with the history and precise condition of the individual, their professional values etc., for treating and managing individual patients. The relative weight given to each of these areas by the HCP is not predetermined, both when clinicians consider healthcare interventions generally, but also when treating and managing individual patients. It is important to understand how HCPs balance factors affecting decision-making and care, in order to understand the level of consistency in managing patient care. Our study focussed on one specific complex and multi-factorial problem, i.e., preventing falls in older people living at home.

Falls occur frequently among older people and represent the most common cause of injury-related morbidity and mortality in later life [4, 5]. The annual incidence of falls among older people ranges between 15% and 35-40% in community-dwelling older people. The consequences of falls range from psychological harm [6], through serious physical injuries [7] and hospitalization, to death [8]. Falls can also reduce overall well-being, mobility, autonomy and quality of life. The risks for falls in old age are complex and it is well known that reducing risk factors [9] and developing interventions [10] can reduce the frequency of falls in community-dwelling older people. Nonetheless, although studies have identified hundreds of risk factors for falls among older people [11, 12, 13], few studies have classified risk factors according to their importance [14, 15, 16].

A recent report [17] reported that current guidelines for preventing falls are not being adhered to and that falls reduction programmes are not evidence-based. How healthcare professionals interpret research evidence in relation to their own experience, and then utilise it with patients in their day-to-day practice, to implement these interventions or assess the relative importance of risk factors for falls is unclear. No research has reported the views of HCPs on how they interpret the research evidence and apply it to falls prevention. A better understanding of the relative importance that HCPs attach to specific risk factors could help to understand why guidelines for preventing falls are not adhered to, as well as improve the effectiveness of interventions and reducing risks for falls in later life. The purpose of our study was to examine the opinions of healthcare professionals involved in the prevention, treatment and management of falls in older people on the relative importance of risk factors for falls. We used the Analytic Hierarchy Process (AHP) [18] to develop a hierarchy of risk factors for falls based on the knowledge and experience of these experts working in the field.

We chose the AHP, as it is particularly effective in quantifying qualitative knowledge by measuring intangible dimensions. This is important because intangible dimension, which can be measured only with qualitative research, cannot be directly measured using an absolute scale [19]. The AHP is an analytic decision-making method, well suited to decisions involving ranking and prioritizing alternatives, as occurs in medical and health care decision-making [20]. It aims to solve multi-factorial and multidimensional problems [21, 22, 23], an example of which is the risk of falls. This method is particularly effective in quantifying opinions, which are based on personal experience and knowledge, to develop a consistent decision framework. This is a crucial point in decision-making processes [24], in which not all the information is objective and quantitative. Often the decision maker bases his/her decision on subjective elements, which can be quantitative or qualitative. The AHP is a particularly useful method for quantifying and comparing subjective data, such as personal background and years of experience, which influences any cooperative decision process.

The overall aim of our study therefore was to use the AHP to help develop a better understanding of the views of HCPs on the relative importance of risk factors for falls in older people. More specifically, the objectives of this study were to: prepare a hierarchy of risk factors for falls among older people based on the available research evidence and expertise and understanding within the research team; develop a questionnaire to elicit opinion on the relative importance of the risk factors for falls within the hierarchy; carry out a survey of experts' views using the questionnaire; analyse the set of responses to prioritize the risk factors for falls in older people.

2. Methods:

We used the Analytic Hierarchic Process (AHP) to prioritize the risk factors, using a Web-based approach, in order to reach a wider number of expert respondents. The study received research ethics approval in accordance with the University of Sheffield research ethics policy.

This method is based on the idea that judging the *relative* importance of risk factors, i.e., comparing pairs of them in a hierarchic structure, is more reliable than judging their absolute importance. Figure 1 presents the flowchart of the method, which is described further in this section.

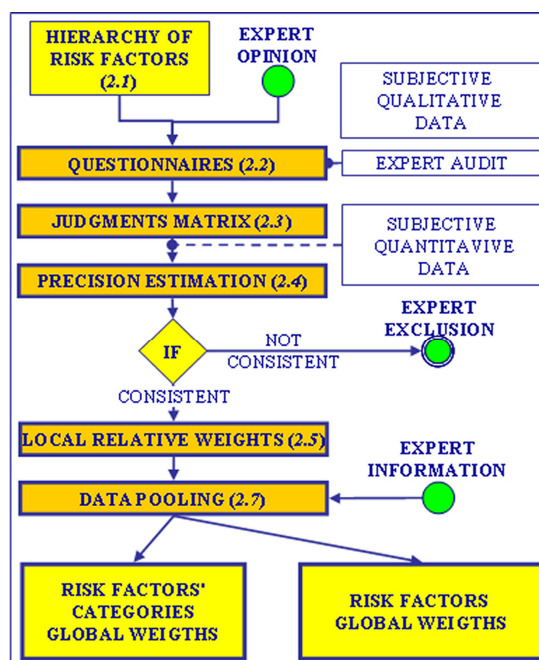


Fig. 1 Flowchart for the AHP

2.1. Hierarchy of risk factors

Using the research literature [9, 10, 11, 12], we identified a range of risk factors for falls. Using our clinical knowledge and the literature, we then 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 and for their overall feedback on the hierarchy. This hierarchy of comparisons aimed to prioritize risk factors and categories of risk factors. This hierarchical approach allows the construction of a consistent step-by-step framework of decision-making, following the assessed paradigm known as *divide et impera* [25].

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 [26], to analyse the responses 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. Similar questions were posed to compare the categories of risk factors.

Although several scales have been proposed [27, 28, 29, 30, 31], we used the Saaty’s natural scale [32], to associate a numerical value to each judgment as reported in table I.

Table I: Saaty Fundamental Scale.

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

Respondents were permitted to use intermediate judgments (as shown in Figure 2), scored with even numbers (positive and negative), to express further insights, or if they could not decide between adjacent categories.



Fig. 2 Detail from the web questionnaire, showing response categories

2.3. Judgments matrix

When the respondents submitted their final answer, from the scores defined in table 1, a web service automatically evaluated for each category of risk factor a judgment matrix $A_{n \times n}$, where “n” is the number of factor in this category. This matrix has as the generic element (a_{ij}) , the ratio between the relative importance of the factor “i” (R_i) and the relative importance of the factor “j” (R_j). Assuming the reciprocity of judgment, the element a_{ji} is the reciprocal of a_{ij} , because if R_i is 3 times more than R_j , then R_j should be 1/3 that of R_i . Moreover, the diagonal elements a_{ii} are equal to one, because R_i is equally to itself. Finally, A is assumed to be a transitive matrix, which means that “ $\forall i, j, k \in (1 ; n), a_{ij} = a_{ik} * a_{kj}$ ”.

This property comes from the definition of a_{ij} , as reported in the following equation:

$$1) \quad a_{ij} = \frac{R_i}{R_j} = \frac{R_i}{R_k} * \frac{R_k}{R_j} = a_{ik} * a_{kj}$$

This is called transitivity property and reflects the idea that if $R_i = a_{ij} * R_j$ and $R_j = a_{jk} * R_k$ then $R_i = (a_{ij} * a_{jk}) * R_k$. It has been proved [32] that, if the judgments are consistent in respect of the transitivity property, this matrix will have each column proportional to the other and so far only one eigenvalue (λ), which will be equal to “n”. The corresponding eigenvector is again proportional to each column, and its

normalized components represent the relative importance of each risk factor within its category. This step was iterated for each category of risk factor. Finally, by applying the same algorithm to the questionnaire on the relative importance of categories, it was possible to evaluate their relative importance overall.

2.4. Consistency, error and precision

In case the judgments are not fully consistent, the columns of the matrix are not proportional, so the matrix has more eigenvectors and none is proportional across all of the columns. For this reason, none is any more representative of the relative importance of each factor. The strategy adopted in this situation was to choose, as the main eigenvector, the one corresponding to the major eigenvalues (λ_{\max}), and to choose its normalized components to represent the relative importance of each factor, as described in paragraph 2.3. This will generate an inconsistency, which can be estimated by posing some redundant questions. Considering three factors i, j , and k , the respondent is asked to perform the pair comparisons $i-k$ and $k-j$, and then the redundant comparison $i-j$. The answer to the redundant question is compared with the one deduced from the first two, assuming the transitivity of judgment, applying equation 1. The difference between the real answer and the transitive one represents the degree of inconsistency. Mathematically, the coherence of each response is modelled as an error: $\text{error}_{ij} = a_{ij} - a_{ik} * a_{kj}$. The global effect of these errors, which reflects the global inconsistency of the respondent, can be estimated measuring the difference of the major eigenvalue λ_{\max} from “ n ”, with an index called the consistency index and which is calculated as: $(\lambda_{\max} - n) / n$. The error is zero when the framework is completely consistent. This error can be seen as a precision error and could be in part due to the scale adopted, which has only natural numbers. For this reason, an error less than 0.1, is usually acceptable [33], as it is the 10% of the minimum step of the judgment scale. Due to the complexity of the task, we permitted a threshold error of 20% as the limit of acceptable consistency: respondents that presented a higher error were excluded from the final data analysis. Typically, an inconsistency measurement greater than 0.1 is

considered too high for reliable decisions [21]; however, we have demonstrated empirically elsewhere [34], that increasing this threshold to 0.2 does not affect significantly the results.

2.5. Assessment of relative importance

After excluding inconsistent respondents and comparing the risk factors, we calculated the Relative Importance index (RI) within each sub-category (termed “intra-categorical weights” or “Local Weights”, LW). According to AHP theory [18, 19], these relative weights are the normalized component of the main eigenvector of the opinion matrix introduced in section 2.3. From the pairwise 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 have to be reported with an imprecision of less than, or equal to, 20%.

2.6. Piloting and respondents

We designed a two-stage pilot study: first, a “technical pilot study” followed by a “scientific pilot study”. The aim of the technical pilot study was to detect and remove technical problems in the web-based questionnaire, i.e., to debug the developed web system, to avoid confusing questions, to improve explanations: this involved researchers from our laboratories in Sheffield and Naples. The aim of the scientific pilot study was to improve the hierarchy, to increase/decrease the number of risk factors, to clarify any clinical aspects related to falls, to estimate the time needed to complete the questionnaire: this involved physicians, physiotherapists and academics with expertise in falls in older people. . In the two pilot studies, the web questionnaire ended with two free-text questions, to elicit comments and suggestions about the hierarchy of risk factors and about the research as a whole.

Finally, with the help of those responsible for the respective Falls sections of the AGILA Chartered Society of Physiotherapy working with older people and the British Geriatrics Society (BGS), an

invitation letter and the link to the reviewed questionnaire was sent by email via the moderator of the respective email distribution lists.

2.7. Data pooling

We pooled the data from the responses of any respondent weighted based on his/her experience, taking into account the following features: years since specialization, level of education, area of work. Although other authors ascribe a different relative importance for each feature, defining a hierarchy of features, we assumed that these features are equally important [35]. Table II presents the assigned weights of each.

Table II: 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
MD 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

3. Results

3.1. Hierarchy of Risk Factors

From the research literature, we individuated a set of 39 risk factors [9, 10, 11, 12], which was reduced to 35 during the pilot study, based on feedback from the respondents. Five factors were excluded (“falls in the previous 12 months”, “capacity to describe causes of previous fall’s”, “loss of control”, “structural diseases”, “cardiovascular medicine”) because they were considered to be confusing or repetitive with respect to other factors. Two further factors were introduced (“poor self rated health” and “previous syncope”) at the suggestion of respondents participating in the pilot study.

We organized the final set of 35 factors into two main categories (Figure 3), “*general risk factors*” and “*clinical risk factors*”, and subdivided these into subcategories.

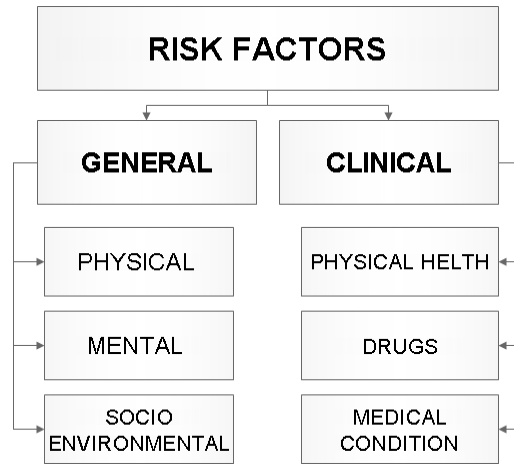


Fig. 3 Risk factors’ hierarchy

General risk factors (Table III) we considered to be those that are not usually pathological, i.e., which could affect 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 III: 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 more especially affect frail older people with various health problems (Table IV). This group includes three sub-categories: *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 IV: 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. Respondents

The technical pilot study, involving 32 respondents, was performed in our labs to define the editorial model trying to minimize the risk of errors. The 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 years' experience), four physiotherapists (with 10, 12, 13 and 13 years' experience) and one professor of physiotherapy comprised the group. Because of their responses, the proposed classification was modified slightly and the included risk factors were reduced from 39 to 35.

191 respondents visited the web questionnaire and, of these, 113 were experts from AGILA and the BGS. Of these, 63 physicians and physiotherapists (55.8%) completed the questionnaires and 56 (88.9% of those completing the questionnaire) completed the questionnaire with the required level of *consistency* (Table V). Although an additional 10 nurses and two academics completed the questionnaire consistently, in this paper we present the results of the 12 physicians and the 44 physiotherapists who completed the questionnaire consistently.

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

	Technical Pilot stusy	Scientific Pilot stusy	Final respondent experts
University	31	1	2
Physicians	1	4	12
Physiotherapists	-	4	44
Nurses	-	-	10
Total	32	9	68

3.3. Data Pooling:

Using the weights introduced above (Table II), the scores attribute by each respondent to each subcategory of Risk Factor, were pooled. The results of this pooling are presented in Figures 4 and 5,

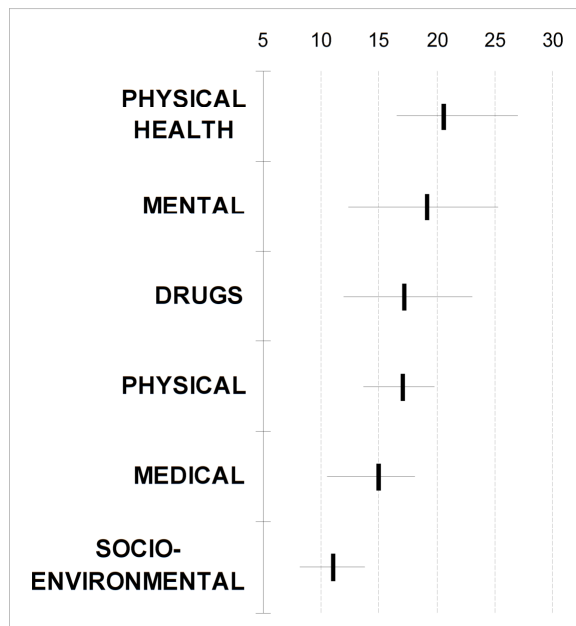


Fig. 4. Graphical representation of relative importance of subcategories of risk factors. Horizontal lines represent the range of opinions among respondents, while the vertical lines represent the global weight (GW).

respectively for categories and risks. For all the sub categories a score (the “inter-categorical weights”) was evaluated, which expresses the relative importance of each sub-category. This score was normalized and expressed as a percentage. The range gives an indication of the data dispersion, which reflects the differences in the opinions among respondents.

Figure 4 shows that sub-category of *physical health* was rated as the most important type of risk factor by the respondents overall, almost

twice that of socio-environmental risk factors. *Drugs*, *physical* and *medical* sub-categories were then considered to be almost equally important. Finally, *medical* and *socio-environmental* factors are listed.

Figure V presents the risk factors’ Global Weights, which represent their relative importance. Figure V shows that “*loss of balance*” was considered to be 5.5 times more important than “*low social services support*” and sedatives and continence problems were both considered to be 4.3 times more important. The horizontal lines report the range of importance attribute to each factor by each respondent. This range is a measure of differences of opinion among responders.

4. Discussion

Our overall aim was to use the AHP to develop a better understanding of the views of HCPs on the relative importance of risk factors for falls in older people. Various studies have investigated risk factors for falls. To the best of our knowledge, few authors have proposed classifications to categorize risk

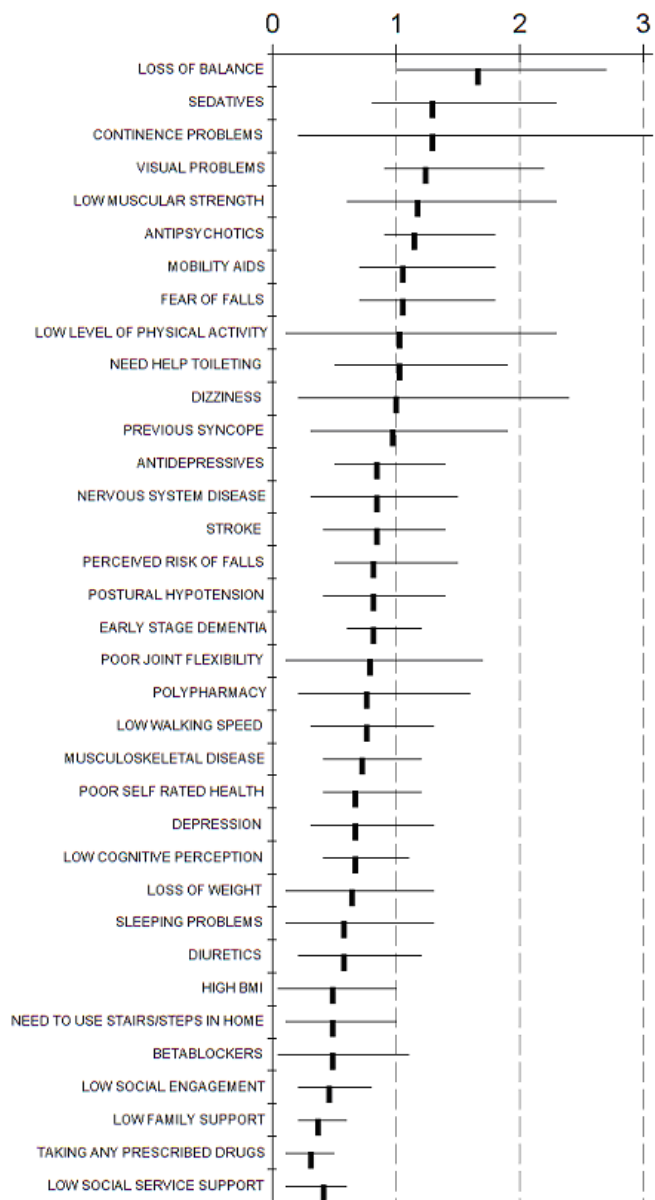


Fig. 4 Graphical representation of relative importance of risk factors. Horizontal lines represent the range of opinions among respondents, while the vertical lines represent the global weight (GW).

factors [11] and none has been based on the opinion of experts from different specializations. The guidelines of the American Geriatrics Society/British Geriatrics Society/ American Academy of Orthopaedic Surgeons suggested classifying these into intrinsic, extrinsic and environmental factors. The UK-based NHS Centre for Reviews and Dissemination (<http://www.york.ac.uk/inst/crd/>) classify the potential risk factors of falls into five major categories: environmental; medication; medical conditions and changes associated with ageing, nutrition, and lack of exercise [13]. With respect to these studies, the ranking we developed provides further insights into clinicians' perceptions of risk factors for falls, presenting a clustering of the priority of risk factors. Although, the difference between the means of consecutive factors is not statistically significant, across the range of mean

values there are clear differences, and it is possible to individuate the factors and the categories of factors that are considered of greater importance. This information is important in developing intervention

programmes for preventing falls. Finally, the ranges in Figure 4 reflect differences in opinion among health care professionals. This may explain why current guidelines for preventing falls are not being adhered to consistently and why not all the programmes to reduce falls are evidence-based [17]. This knowledge should represent the starting point to reduce the existing gap between the systematic use of evidence-based medicine and everyday clinical practice. The proposed hierarchy is a starting point in developing a better understanding of the different views of HCPs on the relative importance of risk factors for falls in older people. This could facilitate the diffusion of guidelines and the designing of evidence-based programmes for falls reduction and thereby improve specialist healthcare services. Previous studies [14, 15, 16] have proposed a classification of most likely causes of falls in elderly people, as reported in 12 empirical studies, as shown in Table VI.

Table VI. 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.

Comparison of our results with this classification is not straightforward. One of the reasons for this is that causes of falls can also be the consequences of other risk factors. An example is drug consumption, which is not considered in Table VI, and which may include psychotropic drugs, which may lead to dizziness, which is itself a risk factor. Conversely, “confusion” is present in table VI but we did not consider, because it could be related to other risk factors, such as “early stage dementia” or use of “sedatives”. Moreover, in this classification, “accident/environmental” is not homogeneous with the other causes, as it a group of causes, similar to our sub-category “socio-environmental”. Nonetheless, if we consider

“weakness” related to “low muscular strength”, the sequential six causes are in the same order of the classification we proposed (see Figure 5), with the exception of “Visual disorders”, which we reported as a fourth factor. However, this apparent difference might be related to “accident/environmental causes”, for which “visual disorders” might be a root cause. As regards to “drop attack”, although in most instances (64%) the risk factors causing a drop attack are never definitively established [36], in about 12% they are related to heart problems, in 8% they are related to circulation problems, and in 8% they are related to problems with both the cardiovascular and the nervous system. The factors included in our hierarchy, which are possible causes of drop attack, are, in order of importance, “previous syncope”, “nervous system disease” and “stroke”. What our study adds to the results of the review of 12 studies presented in Table VI, is a clearer individuation of risk factors, because of the wide ranges reported across the studies. The causes of hospital admission do not investigate risk factors, whether reported by survey or hospital registry; the latter introduces bias by regarding only those falls that require direct hospital care. A further possible explanation for the differences between our ranking and that in Table VI is that there are gaps in knowledge, with the consequence that clinicians are not following guidelines or policy. Our study therefore offers possible reasons for the limited adherence to policy/guidelines reported recently [17].

The hierarchy presented in this paper, which is based on expert knowledge, provides further insights, including underlying, as well as immediate, risk factors for falls, considers all kinds of falls, including those not requiring direct hospital admission. This is important because risk is the combination of the probability of an event and the subsequent effects on the individual. To prevent a fall it is important to focus on all the likely factors, independent of the severity of consequences, because the prevention of falls requires all the potential risk factors be considered. Our hierarchy indicates how falls specialists might prioritise multiple risk factors within individual patients, as well as those risk factors that could be useful for future falls prevention programmes for groups of patients.

Our results led us to believe that, in facing complex healthcare problems, qualitative methods have a role in examining evidence from previous studies [37, 38]. Moreover, it might be useful evidence, not as hierarchically ordered, as in current evidence-based approaches, but as mediation between the context of its use and method of its production. The method behind a study increases the range of admissible evidence in healthcare decision-making [39] and helps to legitimise evidence derived from qualitative studies, as advocated by Kaplan [24], who concluded: *“plea is made for incorporating qualitative/interpretive/subjectivist methods, without prejudice to other approaches. Including such approaches in evaluation research reveals issues that otherwise would not surface.”*

Sensitivity analysis to investigate the effect of the adopted scales on the final solution of the problem has been widely investigated in the literature. In particular, several numerical scales have been proposed, apart from the Saaty fundamental scale, such as the geometrical scale [27, 28, 29] and the Salo-Hamalainen scale [30]. The Saaty scale and the geometrical scale are the most commonly used ones. The Saaty scale has been supported by Saaty’s empirical evidence, but, as mentioned above, it is not a transitive scale. As demonstrated by Dong et al. [31], the geometrical scale is thought to be transitive, however, as Saaty [40] points out that it is difficult to determine the parameters of the geometrical scale.

The individual opinions we obtained were pooled to develop the overall ranking of the risk factors: developing this ranking within a group of experts enables a range of opinions to be incorporated and is less sensitive to the views of a single person. We purposively selected AGILA and the BGS to obtain the views of physiotherapists and geriatricians specialising in falls, and we would expect to obtain similar rankings from other groups of physiotherapists and geriatricians. Further research could explore whether a similar ranking would be obtained from other groups of clinicians involved in the care of older people and/or falls services.

As discussed in the previous sections, to pool the data obtained from different experts it is important to weight appropriate features of the respondents. The adopted weighting system is summarized in Table II.

The spread of the relative importance of the risk factors according to the opinions expressed 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 might have been less diverse. In fact, different groups of community-dwelling older people might have relatively different risk factors for falls. Concerning the risk factors, this spread does not allow a significant classification of each factor, because of the overlapping range between consecutive factors. Nonetheless, it is clear that loss of balance is considered the single most important risk factor. Factors between “*sedative*” and “*need help toileting*” are classified with small differences among them, although these are clearly considered to be within the top ten risk factors.

There were a number of limitations with our study. First, the number of respondents who were included in the final analysis (n=56) was restricted, and a number of respondents were excluded either because they did not complete the questionnaire or because their responses were not consistent, as explained in section 2.4. Using a web-based questionnaire allowed us to reach a wider number of respondents but meant we had to exclude the respondents from the study who did not reach the threshold level of consistency, rather than ask them to repeat all, or parts of, the questionnaire, which is possible when the questionnaire is used face-to-face. An intrinsic aspect of the AHP methodology is that inconsistent respondents cannot be included in the analysis [33]; previous research has demonstrated that increasing this threshold to 0.2 does not significantly change the results [34]. The reason for not including inconsistent respondents is that if the judgments are wholly consistent, all the columns of the matrix are proportional to each other. The matrix has one eigenvector, which is proportional to all the columns. This eigenvector is representative of the relative importance of each factor. If the judgments are not wholly consistent, the columns of the matrix are not proportional, so the matrix has more eigenvectors and none is proportional to any of the

columns. For this reason, no eigenvector is representative of the relative importance of each factor anymore.

A limit of the web-based approach we adopted was that it was not possible to discuss with respondents, why they considered one factor more important than another. It is therefore not wholly clear why the HCPs ranked each risk factor as they did, or on the criteria that individual respondents used in making their judgements, e.g., whether they based it on the severity of the consequences, or on the prevalence of specific risk factors. However, this ranking is a starting point for developing a better understanding of the perceived importance of risk factors for falls, and why guidelines and policies for prevention are not followed. The next step would require further research on this would provide deeper insights into how they ranked the risk factors, and the criteria they used for their decision-making, particularly those risk factors that were viewed as being more important.

Since human judgment cannot be completely consistent, the transitivity property could be not fully respected every time, especially when many factors are compared. Furthermore, the scale proposed in Table I contain only natural numbers and this is a mathematical limit to achieve full transitivity every time. The AHP operates using a pair wise comparison of risk factors and pool these comparisons to develop the overall ranking within the sample; therefore, it is not possible to compare the overall rankings across the sample, e.g., using Kendall's Coefficient of Concordance. However, future research could quantify the level of consensus and disagreement among the respondents, for example by asking them to rank the list risk factors altogether and then undertaking such a statistical test.

A further issue requiring consideration is the tendency of individuals to modify their views over time in response to changes in research evidence, clinical experience and the environment within which they operate. This issue similarly affects the validity of scales of measurement, which on the one hand need to be relatively stable over short periods of time, but also sensitive to capture real changes in the domain being measured. While clinicians' assessment of the relative importance of different risk factors for falls

might be modified over time, e.g., in response to new research evidence, over short periods of time we are confident that the opinions would be relatively stable and any small fluctuations within individuals would not adversely affect the overall rankings of the risk factors for falls observed in our study.

Conclusion

Falls in home-dwelling older people are a complex, and multi-factorial, phenomenon and few studies have classified risk factors. In this study, we used the AHP to develop a better understanding of the views of HCPs on the relative importance of risk factors for falls in older people. The study ranked 35 risk factors, organized into six logical categories, based on the subjective opinions of experts in the field. The derived classification is consistent with objective rankings from previous studies and provides further knowledge on a wider range of factors, as well as individuating risk factors more clearly.

The classification is useful for understanding the relative importance that clinicians place on risk factors for falls in older people, both for developing intervention programmes, but also for understanding how they prioritise multiple risk factors in individual patients. This may also help in understanding why clinicians do not always follow evidence-based guidelines and policy for specific patients, and be useful for informing encouraging clinicians to adhere to guidelines.

As a method, the AHP is particularly effective in quantifying qualitative knowledge by measuring intangible dimensions, particularly in trying to understand complex processes. It also helps to substantiate evidence derived from qualitative research, which is still needed in medical and health research, due to the complexity of the field. Finally, using the AHP method, we have shown that there are differences in the opinions of experts on the relative importance of risk factors for falls. This may be one reason why current guidelines are not being adhered to consistently. Understanding these differences, and then developing a clearer consensus on risk factors, could facilitate the diffusion of evidence-based programs to reduce falls and thereby improve healthcare services for older people.

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