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# Identifying patterns of multimorbidity, polypharmacy and frailty in the elderly: a clustering analysis of baseline data from a French, randomised, controlled trial in primary care

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## ABSTRACT

**Objectives** To identify distinct profiles among elderly patients in primary care so that general practitioners (GPs) can develop more targeted care strategies.

**Design** A cross-sectional analysis of baseline data from the French nationwide 'Elderly Appropriate Treatment in Primary Care' trial.

**Setting** Primary care in France: 277 GPs included patients.

**Participants** The study participants were aged 75 or over, living at home, and taking five or more prescription medications. Of the 2724 patients included, 2651 were analysed.

**Primary and secondary outcome measures** To identify specific patterns of multimorbidity, polypharmacy and frailty, we applied an unsupervised clustering analysis with self-organising maps.

**Results** Seven clusters were identified: cluster 1 (16% of the patients) comprised frail men and women with cardiovascular, respiratory, musculoskeletal and endocrine diseases and marked polypharmacy; cluster 2 (9.3%, mainly men) comprised frail patients with cancer and cardiovascular or urogenital/renal diseases; cluster 3 (15.5%, mainly men) comprised not-very-frail patients with cardiovascular and urogenital/renal diseases; cluster 4 (18.1%) comprised not-very-frail men and women with cardiovascular diseases; cluster 5 (13.5%, mainly women) comprised mainly lonely, very frail patients with hypertension and endocrine, musculoskeletal and neuropsychiatric disorders; cluster 6 (19.1%, mainly women) comprised frail, socially isolated patients with digestive, musculoskeletal and neuropsychiatric diseases; lastly, cluster 7 (8.6%, mainly women) comprised frail, socially isolated patients with hypertension, cancer, or musculoskeletal, psychological and digestive disorders.

**Conclusion** Our phenotypic classification of elderly patients might facilitate efforts to align healthcare services with the care needs that are encountered by GPs in their everyday practice.

**Trial regestration number** (NCT03298386).

## STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study was based on a fairly large, exhaustive, high-quality dataset collected from elderly patients in primary care.
⇒ The study sample was representative of general practitioners in France and elderly patients with multimorbidity and polypharmacy in France.
⇒ The data on diseases, treatments, frailty and socioeconomic factors were collected prospectively, using standardised instruments.
⇒ Our patient-centred and community-centred approach was designed to improve the well-being and care of this population.
⇒ It might not be possible to extrapolate our results to fields outside primary care or to countries with different healthcare systems.

## INTRODUCTION

Population ageing has emerged as social, medical and economic challenge in general and as a risk factor for multimorbidity in particular.[1] In turn, multimorbidity is associated with poor quality of life and poor health outcomes, such as disability, psychological distress, hospital admission and excess mortality.[2–7] Furthermore, patients with chronic diseases tend to take more medications on a regular basis[8] and consult several prescribers. Polypharmacy is particularly likely to generate adverse outcomes in older adults: iatrogenic disorders, adverse drug events, a greater risk of mortality, impaired functional status and greater use of healthcare resources.[9–12] Age-related changes in biological processes and conditions may lead to frailty,[13] which is also associated with adverse health outcomes.[14] Thus, the generalised, rapid ageing of the population requires complex, well-structured healthcare planning. Unhealthy ageing raises serious

concerns because it has many social and economic consequences, including greater demand for healthcare and social security support—particularly in high-income countries with welfare-based social care systems.[15]

As in many other countries, a large proportion of elderly patients in France are managed in primary care. The general practitioner (GP)'s goal is to assess the individual's medical and social needs and coordinate the provision of effective care. It is important for the GP to understand the inherent multidimensionality and complexity of ageing, which is influenced by multimorbidity, polypharmacy, frailty and socioeconomic environment. However, this evaluation is complicated by the high level of heterogeneity in the elderly population. Knowledge of multimorbidity patterns in the elderly has important implications for patient-oriented (rather than disease-oriented) prevention, diagnosis, treatment and prognosis strategies. The objective of the present study was to identify distinct patient profiles among elderly adults in primary care.

## METHOD

### Study design, setting and data sources

The baseline data from the 'Elderly Appropriate Treatment in Primary Care' (EAT) trial were fed into an unsupervised clustering analysis. EAT is a French, nationwide, prospective, multicentre trial that included elderly patients with polypharmacy. The study participants were recruited in primary care units between July 2017 and September 2018. The objective of the EAT trial was to assess the effectiveness of a GP-targeted intervention (a medication review, using the STOPP/START tool) for decreasing morbidity and mortality rates among elderly patients with polypharmacy (NCT03298386). Volunteer GPs were assigned randomly to the intervention group or the standard care (control) group, and participants were followed up for 12 months. Only data collected at visit 0 (before any intervention) were analysed in the present study. Patients with missing data were excluded from the analysis.

### Selection and recruitment

The principal investigator invited 40 regional investigators from across France to participate in the study. In turn, each regional investigator recruited and managed 10 GPs, each of whom was asked to include 10 patients with polypharmacy (ie, taking at least five prescription medicines) aged 75 or over, living in their own home, and who were not expected to die in the following 12 months. Patients were included regardless of the reason for their consulting the GP.

### Patient and public involvement

Patients were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

### Variables

The following variables were recorded via an electronic case report form: demographic variables (sex, age and working status before retirement), lifestyle variables, smoking status (current, never or ex-smokers), social support (living alone, regular help, presence of an informal or professional caregiver, and material assistance) and health insurance status (notably the French state's provision of free healthcare cover for individuals whose income is below a set level, the daily living allowance for patients aged over 60, and chronic disease status for greater reimbursement of healthcare costs).

Diseases and comorbidities were noted and classified using the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM). The names of prescription drugs were also recorded. Active compounds were coded according to the Anatomical Therapeutic and Chemical (ATC) classification; in the present study, only ATC first level groups are reported. Frailty was assessed using the modified Short Emergency Geriatric Assessment (SEGAm) Instrument.[16]

### Descriptive analyses

The patients were characterised in terms of sociodemographic variables, lifestyle factors, multimorbidity, polypharmacy and frailty. Descriptive results are presented as the frequency (percentage) for categorical variables and the mean±SD or the median (IQR) for continuous variables, depending on the normality of distribution.

### Cluster analysis

In a pragmatic approach, clusters were built according to the predefined disease domains, age, sex and the number of prescription drugs. We first performed a dimensional reduction. A mixed principal component analysis was performed using the package pcamixdata of the R software. To account for the binary nature of the variables, a multiple correspondence analysis was used to compute continuous predicted scores as the input data for the clustering analysis. We calculated Pearson's coefficient (ρ) for the correlation between a pair of variables; if the two were substantially correlated (ρ>0.6), only the variable with the greater clinical significance was selected.

Self-organised maps (SOMs) were built using the *Numero* framework for R[17 18] and a circular implementation. This unsupervised, non-parametric approach is based on Kohonen's neural networks and can convert multidimensional datasets with large numbers of variables into visually simplified, two-dimensional grids.[19] SOM algorithms map individuals to specific zones, based on their characteristics: similar individuals are grouped near to each other, while dissimilar individuals are positioned further apart. This approach enables visual comparisons that highlight characteristics shared by patients or that distinguish between them. Given that no statistical approach could provide definite guidance on the number of clusters and the cluster boundaries at the time of analysis, an expert-driven approach was used to group the patients according to the visualised data patterns and key characteristics. We also performed a more conventional cluster analysis, using k-means. Much as in the main analysis, we

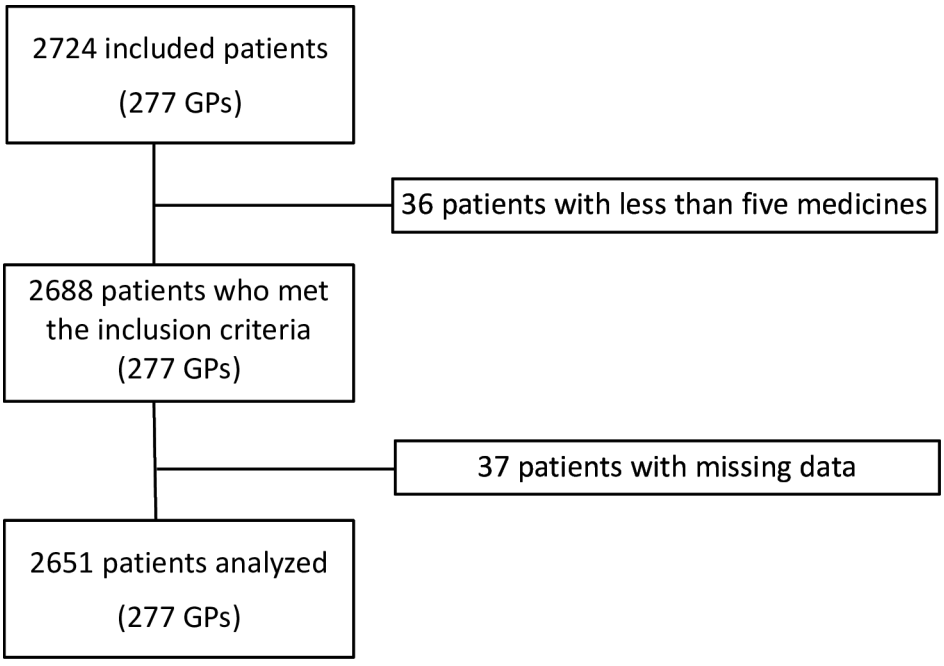


**Figure 1** Study flow chart.

used the results of the principal component analysis as the input for the k-means clustering.

### Group comparisons

Groups identified in the clustering analysis were compared in a one-way analysis of variance, in the Kruskal-Wallis tests for continuous variables or in a $x^2$ test or Fisher's exact test for categorical variables, as appropriate. The threshold for statistical significance was set to $p<0.05$.

Stata 17.0 software (StataCorp, Tx, USA) was used for descriptive analyses and group comparisons, and R software (version 4.1.1, with the Numero package version 1.2.0) was used for clustering analyses and data visualisation.[20]

## RESULTS

### Participants

Data on 2651 patients (followed up by 277 GPs) were analysed. The study population corresponded to 97.3% of the patients screened by the GPs (figure 1). The patients' median (IQR) age at inclusion was 83 (79–87), and 1571 (59%) were women (table 1). The median (IQR) number of diseases per patient was 4[3–6] (figure 2). The median (IQR) number of drugs per patient was 8[6–9] (figure 3). Twelve per cent of the patients were very frail, 21% were frail and 67% were not-very-frail.

### Clustering analysis

There were no significant correlations between the variables selected for the cluster analysis (online supplemental figure S1). The analysis of variance allowed us to select 10 dimensions that explained ~95% of the cumulative variance in the original data (online supplemental table S1). Seven clusters were identified (figure 4).

Cluster 1 (n=423, 16%) comprised similar numbers of men and women. One third of the cluster members were ex-smokers. The main diseases were cardiovascular (mainly atrial fibrillation, heart failure, coronary artery disease and lower limb peripheral artery disease), respiratory (asthma, chronic obstructive pulmonary disease and sleep apnoea syndrome), musculoskeletal (mainly osteoarthritis) and endocrine (diabetes and thyroid disorders). The median (IQR) number of drugs was 10,[8–12] and one third of the patients were frail or very frail. Three-quarters received professional or material assistance, and 88% had social security support for a chronic disease.

Cluster 2 (n=247, 9.3%) was predominantly male, and 39% were ex-smokers. The main diseases were cardiovascular (atrial fibrillation, heart failure, coronary artery disease, lower limb peripheral artery disease and stroke), cancer (mainly prostate, colorectal and skin cancer) and urogenital/renal (mainly dysuria due to prostate diseases, and kidney failure). The median (IQR) number of drugs was 7,[6–9] and one third were frail or very frail. Less than a third of the patients were living alone, and 95% received social security support for a chronic disease.

Cluster 3 (n=410, 15.5%) was predominantly male, and 42% were former smokers. The main diseases were cardiovascular diseases (atrial fibrillation, heart failure, coronary artery disease and stroke) and urogenital/renal problems (mainly dysuria due to prostate diseases, and kidney failure). The median (IQR) number of drugs was 7,[6–9] and 74% were not-very-frail. Less than a third of the patients were living alone.

Cluster 4 (n=479, 18.1%) contained more women than men, and 82% were never-smokers. The main diseases were cardiovascular (atrial fibrillation, heart failure, coronary artery disease and stroke). The median (IQR)

**Table 1** Characteristics of the study population

| Patient characteristics | (N=2651) | N (%) |
|---|---|---|
| Demographics | | |
| | Age (years), median (IQR) | 83 (79; 87) |
| | Sex (women) | 1571 (59.3) |
| Professional activity before retirement | | |
| | Farmers | 247 (9.32) |
| | Craftspeople, shopkeepers and business owners | 308 (11.6) |
| | Executives and intellectual professions | 228 (8.60) |
| | Employees | 732 (27.6) |
| | Workers | 449 (16.9) |
| | Intermediate occupations | 269 (10.2) |
| | No professional activity | 418 (15.8) |
| Lifestyle, assistance and social support | | |
| | Lives alone | 1186 (44.7) |
| | Regular help | 1233 (46.5) |
| | Caregiver | 873 (70.8) |
| | Professional/ material assistance | 898 (72.8) |
| | Health insurance/ coverage status | 2208 (83.3) |
| | Chronic disease status | 2166 (81.7) |
| | Daily living allowance | 316 (11.9) |
| | Free healthcare cover | 9 (0.34) |

number of drugs was 7,[6–8] and 84% were not-very-frail. Almost one half were living alone.

Cluster 5 (n=359, 13.5%) was predominantly female, and 92% were never-smokers. The main diseases were cardiovascular (mainly high blood pressure), endocrine (diabetes and hypothyroidism), musculoskeletal (osteoarthritis and osteoporosis) and neuropsychiatric (anxiety, depression and dementia). The median (IQR) number of drugs was 7,[6–9] and half of the patients were frail or very frail. More than half were living alone, 58% received regular help, 79% received professional or material assistance, and 17% received the daily living allowance.

Cluster 6 (n=505, 19.1%) was predominantly female, and 85% were never-smokers. The main diseases were digestive (gastro-oesophageal reflux disease and constipation), musculoskeletal (osteoarthritis and osteoporosis) and neuropsychiatric (anxiety, depression and dementia).

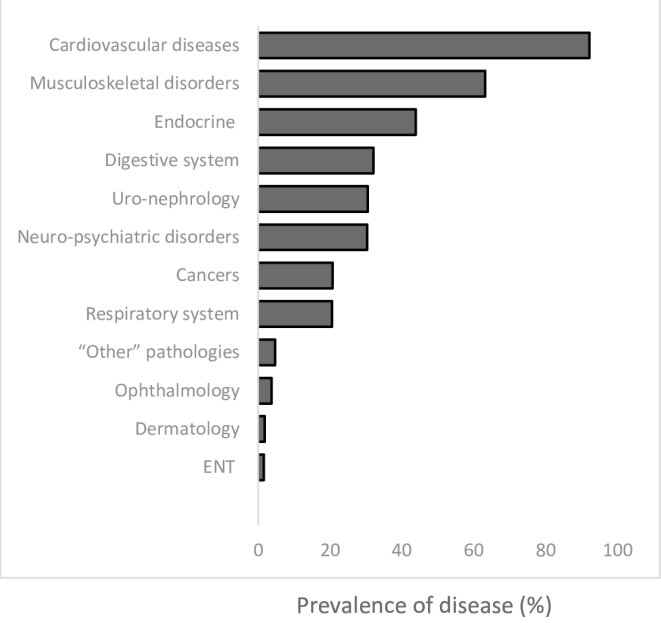


**Figure 2** Prevalence of diseases, by main domain.

The median (IQR) number of drugs was 8,[6–9] and 40% were frail or very frail. More than one half were living alone, 54% received regular help, and 15% received the daily living allowance.

Cluster 7 (n=228, 8.6%) was predominantly female, and 95% were never-smokers. The main diseases were cardiovascular (mainly arterial hypertension), cancer (breast, colon and skin cancer), musculoskeletal (osteoarthritis and osteoporosis), psychological (anxiety and depression) and digestive (gastro-oesophageal reflux). The median (IQR) number of drugs was 8,[7–10] and 39% were frail or very frail. More than half were living alone, 54% received regular help, and 88% received social security support for a chronic disease.

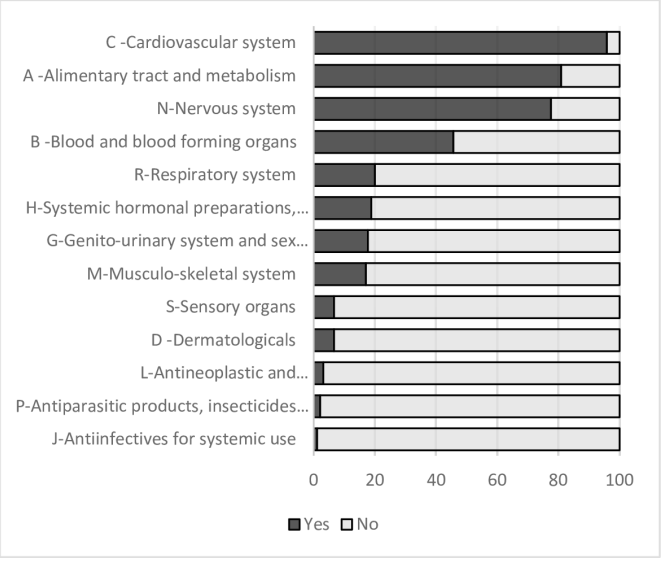


**Figure 3** Prevalence of medications taken, according to the ATC level 1 classification. ATC, Anatomical Therapeutic and Chemical.

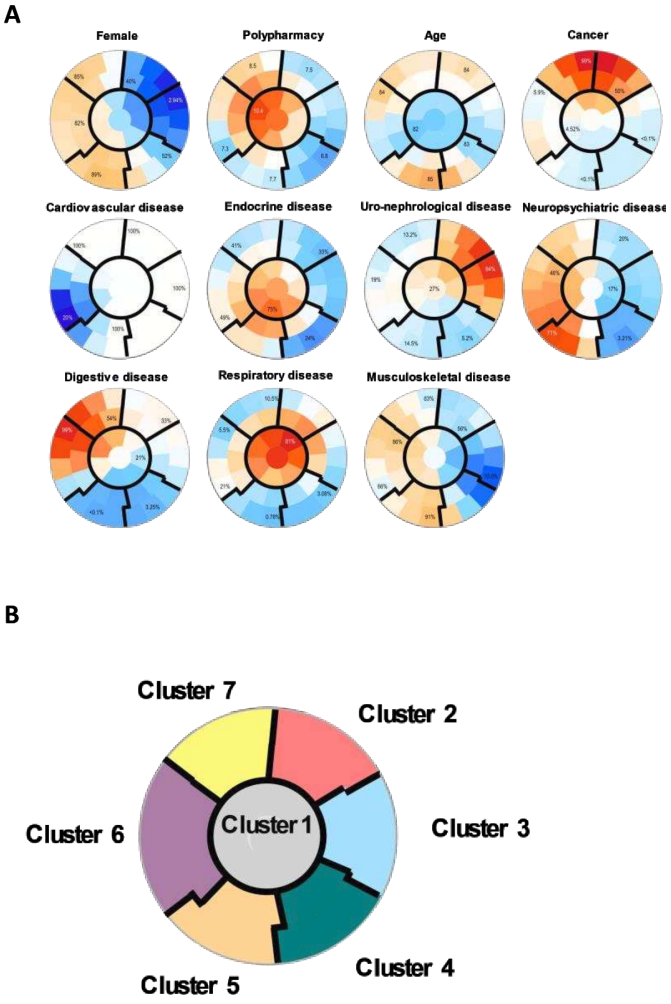


**Figure 4** The results of the clustering analysis (using self-organised maps (SOMs)) for patient characteristics. *An unsupervised SOM analysis placed all patients identified as generally similar within 1 of 40 small groupings (districts) throughout the map: the more similar the patients, the closer they are on the map. Each individual map shows the prevalence values per district for each characteristic. The lowest mean values are indicated in blue, and the highest are indicated in red. Numbers are specified for a selection of representative districts in each SOM. Based on expert-driven, visual identification of key patterns in the SOMs, close districts were combined into seven patient clusters. Cluster boundaries are delimited by solid black lines.*

Details of the sociodemographic and socioprofessional variables, smoking status, social care and diseases by cluster are given in table 2 and online supplemental table S1.

The results of the k-means clustering are given in online supplemental tables S3 and S4. Online supplemental figure S3 illustrates patients in clusters generated using the SOM and the k-means methods. Clusters K1 (cluster 1 from the k-means), K3 and K6 are similar to clusters S1 (cluster 1 from SOM), S3 and S6, respectively. Cluster K2 included patients from S4, S5 and S6, while cluster K4 consisted of patients from S4 and S5. None of the k-means clusters showed a high prevalence of musculoskeletal, neuropsychiatric and digestive diseases, as was the case for S6. Similarly, none of the k-means clusters exclusively included frail patients with cardiovascular, musculoskeletal, neuropsychiatric and endocrine diseases, as was the case for S5. K5 appeared to be a blend of clusters S4 and S5; all patients in these clusters had cancer and cardiovascular disease. However, S4 was predominantly male and S7 was predominantly female, making K5 a mixed-sex cluster. Overall, the clusters identified using an expert-driven SOM approach were more refined than those derived from k-means.

## DISCUSSION

### Summary

We identified seven distinct clusters among frail elderly adults with multimorbidity and polypharmacy. The clusters did not differ significantly with regard to age. We observed clusters with mild multimorbidity (mainly comprising women, with cardiovascular risk factors, digestive and musculoskeletal disorders, together with neuropsychiatric disorders in clusters 5 and 6 and cancer in cluster 7) and clusters with severe multimorbidity (mainly comprising men with cardiovascular diseases (clusters 3 and 4) plus cancer (cluster 2) or other serious diseases (cluster 1)). Although the clusters did not differ greatly with regard to polypharmacy (apart from cluster 1), there were significant differences in frailty. Cluster 5 included the frailest patients: these were mostly lonely, very frail women, with mild multimorbidity but neuropsychiatric disorders requiring complex medical, psychological and social care. Cluster 6 also included frail patients: this cluster of frail, multimorbid, elderly women suffering from various diseases represents a challenge for primary care teams. Clusters 2 and 7 included frail men and women with cancer (mainly prostate cancer in cluster 2 and breast cancer in cluster 7) and an additional cardiovascular disease or age-related multimorbidity. These frail, multimorbid elderly patients with cancer have complex care needs. Cluster 1 also featured frail patients with high levels of multimorbidity and polypharmacy, for whom a GP-led medication review is challenging. Clusters 3 and 4 featured less frail patients with cardiovascular disease and (for the men in cluster 3) dysuria. In these two clusters (accounting for a third of the patients), prevention is probably essential for avoiding or delaying progression to greater levels of frailty and multimorbidity.

### Comparison with existing literature

Our results on the prevalence of multimorbidity, polypharmacy and frailty are consistent with previous studies conducted in France.[21–24] Furthermore, the polypharmacy and drug class data reported in the present study are consistent with general trends for prescriptions by GPs in France.[21] The clustering results differ significantly from one literature study to another, due to variations in methods, data sources, populations and healthcare systems.[25] The majority of previous studies were carried

**Table 2** The main characteristics of the patients by cluster, according to self-organised maps

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| | (n=423, 16%) | (n=247, 9.3%) | (n=410, 15.5%) | (n=479, 18.1%) | (n=359, 13.5%) | (n=505, 19.1%) | (n=228, 8.6%) | P value |
| **Summary description** | **Mixed-sex, frail, major multimorbidity and polypharmacy** | **Men, frail, severe multimorbidity with cancer** | **Men, not very frail, severe multimorbidity** | **Mixed-sex, lonely, not very frail, severe multimorbidity** | **Women, lonely, very frail, mild multimorbidity, neuropsychiatric disorders** | **Women, lonely, frail, mild multimorbidity, neuropsychiatric disorders** | **Women, lonely, frail, mild multimorbidity, cancer, psychological disorders** | |
| Demographics | | | | | | | | |
| Age (years), median (IQR) | 81 (79; 85) | 83 (80; 88) | 83 (79; 86) | 83 (80; 87) | 84 (80; 87) | 83 (80; 87) | 83 (80; 87) | **<0.0001** |
| Sex, women (%) | 238 (56.3) | 34 (13.8) | 32 (7.8) | 317 (66.2) | 331 (92.2) | 410 (81.2) | 209 (91.7) | **<0.0001** |
| Former professional activity | | | | | | | | |
| Farmers, n (%) | 37 (8.75) | 29 (11.7) | 34 (8.29) | 48 (10.0) | 36 (10.0) | 41 (8.12) | 22 (9.65) | **<0.0001** |
| Craftspeople, shopkeepers and business owners | 56 (13.2) | 39 (15.8) | 63 (15.4) | 55 (11.5) | 32 (8.91) | 47 (9.31) | 16 (7.02) | |
| Executives/ intellectual professions, n (%) | 39 (9.22) | 29 (11.7) | 62 (15.1) | 38 (7.93) | 10 (2.79) | 34 (6.73) | 16 (7.02) | |
| Employees, n (%) | 109 (25.8) | 59 (23.9) | 98 (23.9) | 131 (27.4) | 121 (33.7) | 141 (27.9) | 73 (32.0) | |
| Workers | 83 (19.6) | 51 (20.7) | 87 (21.2) | 75 (15.7) | 53 (14.8) | 66 (13.1) | 34 (14.9) | |
| Intermediate occupations, n (%) | 42 (9.93) | 27 (10.9) | 55 (13.4) | 46 (9.60) | 24 (6.69) | 51 (10.1) | 24 (10.5) | |
| No professional activity, n (%) | 57 (13.5) | 13 (5.26) | 11 (2.68) | 86 (18.0) | 83 (23.1) | 125 (24.8) | 43 (18.9) | |
| Lifestyle, assistance and social support | | | | | | | | |
| Living alone, n (%) | 173 (40.9) | 72 (29.2) | 113 (27.6) | 231 (48.2) | 208 (57.9) | 267 (52.9) | 122 (53.5) | **<0.0001** |
| Regular help, n (%) | 202 (47.8) | 107 (43.3) | 140 (34.2) | 180 (37.6) | 208 (57.9) | 272 (53.9) | 124 (54.4) | **<0.0001** |
| Caregiver, n (%) | 153 (75.7) | 79 (73.8) | 100 (71.4) | 117 (65.0) | 154 (74.0) | 187 (68.8) | 83 (66.9) | 0.22 |
| Professional/ material assistance, n (%) | 154 (76.2) | 79 (73.8) | 95 (67.9) | 113 (62.8) | 164 (78.9) | 202 (74.3) | 91 (73.4) | **0.01** |
| Chronic disease status, n (%) | 373 (88.2) | 234 (94.7) | 339 (82.7) | 366 (76.4) | 299 (83.3) | 354 (70.1) | 201 (88.2) | **<0.0001** |
| Daily living allowances, n (%) | 57 (13.48) | 22 (8.91) | 31 (7.56) | 39 (8.14) | 62 (17.27) | 75 (14.9) | 30 (13.2) | **<0.0001** |
| Smoking status | | | | | | | | |

Continued

**Table 2** Continued

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| | (n=423, 16%) | (n=247, 9.3%) | (n=410, 15.5%) | (n=479, 18.1%) | (n=359, 13.5%) | (n=505, 19.1%) | (n=228, 8.6%) | P value |
| **Summary description** | **Mixed-sex, frail, major multimorbidity and polypharmacy** | **Men, frail, severe multimorbidity with cancer** | **Men, not very frail, severe multimorbidity** | **Mixed-sex, lonely, not very frail, severe multimorbidity** | **Women, lonely, very frail, mild multimorbidity, neuropsychiatric disorders** | **Women, lonely, frail, mild multimorbidity, neuropsychiatric disorders** | **Women, lonely, frail, mild multimorbidity, cancer, psychological disorders** | |
| Ex-smoker, n (%) | 133 (31.4) | 97 (39.3) | 173 (42.2) | 82 (17.1) | 24 (6.69) | 65 (12.9) | 11 (4.82) | **<0.0001** |
| Current smoker, n (%) | 23 (5.4) | 5 (2.02) | 11 (2.68) | 6 (1.25) | 5 (1.39) | 12 (2.38) | 1 (0.44) | |
| Never-smoker, n (%) | 267 (63.2) | 145 (58.7) | 226 (55.1) | 391 (81.6) | 330 (91.9) | 428 (84.8) | 216 (94.7) | |
| Diseases | | | | | | | | |
| Cancer, n (%) | 33 (7.8) | 247 (100) | 0 (0) | 0 (0) | 0 (0) | 42 (8.3) | 228 (100) | **<0.001** |
| Cardiovascular, n (%) | 422 (99.8) | 247 (100) | 410 (100) | 479 (100) | 359 (100) | 299 (59.2) | 228 (100) | **<0.001** |
| Endocrine, n (%) | 251 (59.3) | 88 (35.6) | 142 (34.6) | 110 (23) | 240 (66.9) | 234 (46.3) | 99 (43.4) | **<0.001** |
| Urogenital and renal, n (%) | 110 (26) | 153 (61.9) | 358 (87.3) | 16 (3.3) | 54 (15) | 98 (19.4) | 21 (9.2) | **<0.001** |
| Neuropsychiatric, n (%) | 123 (29.1) | 45 (18.2) | 91 (22.2) | 9 (1.9) | 231 (64.4) | 221 (43.8) | 86 (37.7) | **<0.001** |
| Digestive, n (%) | 150 (35.5) | 78 (31.6) | 135 (32.9) | 10 (2.1) | 0 (0) | 363 (71.9) | 115 (50.4) | **<0.001** |
| Respiratory, n (%) | 365 (86.3) | 59 (23.9) | 50 (12.2) | 1 (0.21) | 2 (0.56) | 54 (10.7) | 15 (6.58) | **<0.001** |
| Musculoskeletal, n (%) | 288 (68.1) | 128 (51.8) | 169 (41.2) | 229 (47.8) | 310 (86.4) | 392 (77.6) | 160 (70.2) | **<0.001** |
| Polypharmacy | | | | | | | | |
| Number of medications taken, median (IQR) | 10 (8; 12) | 7 (6; 9) | 7 (6; 9) | 7 (6; 8) | 7 (6; 9) | 8 (6; 9) | 8 (7; 10) | **<0.001** |
| Risk of frailty, according to the SEGAm | | | | | | | | |
| Not very frail, n (%) | 270 (63.0) | 157 (63.6) | 302 (73.7) | 404 (84.3) | 192 (53.5) | 302 (59.8) | 140 (61.4) | **<0.001** |
| Frail, n (%) | 101 (23.0) | 57 (23.1) | 69 (16.8) | 62 (12.9) | 94 (26.2) | 132 (26.1) | 57 (25.0) | |
| Very frail, n (%) | 52 (12.3) | 33 (13.4) | 39 (9.50) | 13 (2.70) | 73 (20.2) | 71 (14.1) | 31 (13.6) | |

The bold values represent statistically significant p-values ($p < 0.05$).
SEGAm, modified Short Emergency Geriatric Assessment.

out in hospital facilities or were based on retrospective data from clinical administrative databases or self-reported questionnaire data. None of the studies sought to identify combined multimorbidity, polypharmacy and frailty patterns in an elderly population. In a recent study, Olson *et al*[26] used a clustering approach to identify subgroups of older adults with polypharmacy. Six clusters were identified: patients with good functional status, females with moderate-to-severe pain, patients with a poor prognosis needing functional status assistance, patients with poor functional status, males with an adult child as the primary caregiver, and adults living alone with the spouse as the primary caregiver. In a Spanish retrospective study of an elderly population,[27] a mapping process was used to identify combined multimorbidity and polypharmacy patterns. Of the seven clusters identified, one was non-specific (cluster 1) and six were specific and corresponded to diabetes (cluster 2), neurological and musculoskeletal diseases with female predominance (clusters 3 and 4), cardiovascular, cerebrovascular and renal diseases (cluster 5), cardiovascular, renal, inflammatory and respiratory diseases (cluster 6), and multisystem diseases (cluster 7).

## Strengths and limitations

Our study had several strengths. First, it was based on a fairly large, exhaustive, high-quality dataset collected from elderly patients in primary care. Second, our sample was representative of GPs in France and elderly patients with multimorbidity and polypharmacy in France. Third, the data on diseases, treatments, frailty and socioeconomic factors were collected prospectively using standardised instruments; this is a major advantage with regard to the literature studies based either on social security databases or self-reported data. Fourth, the proportion of missing data was low. Lastly, we adopted a patient-centred and community-centred approach[28] that was designed to improve the well-being and care of this population.

Our study also had some limitations. First, the patients were recruited in France only; it might not be possible to extrapolate the results to fields outside general practice or to countries with different healthcare systems. Second, the study's findings are specifically relevant to primary care and might not directly apply to other healthcare settings. Third, certain highly prevalent diseases (such as lung cancer in men) were rarely observed in our study population. This might be due to the poor prognosis for this disease and the fact that the study did not include patients with a life expectancy of less than 12 months. Lastly, our clustering approach was based on SOMs, and other algorithms might yield slightly different results.

## Implications for research and practice

Our study provided a detailed, quantitative overview of health status and social conditions among elderly adults in primary care. The results highlighted the heterogeneity of health needs among elderly adults, the complex interplay between diseases, treatments, and the patient's socioeconomic environment, and the resulting difficulty in resource planning. The SEGAm instrument is easy to apply in primary care and is particularly suitable for identifying elderly people with modifiable frailty factors and who might benefit from early interventions (eg, those in clusters 1, 2, 5, 6 and 7).

GPs should be able to identify three levels of multimorbidity, depending on the level of resource use: (i) mild multimorbidity with little frailty and limited disability, that is, requiring prevention, self-care and access to primary care (none of the clusters in our population corresponded to this profile); (ii) severe multimorbidity with little frailty and limited disabilities (clusters 3 and 4), or mild multimorbidity with severe frailty and severe disabilities (clusters 5, 6 and 7), that is, requiring primary care and social support, with a risk of hospital admission; and (iii) severe multimorbidity with severe frailty, severe disability (clusters 1 and 2), and the intensive use of hospital care resources. On this basis, GPs could effectively prevent disease, maintain physical function and mental health, and implement resources that promote autonomy, quality of life and healthy ageing.

More targeted studies of multimorbidity, polypharmacy and frailty in the elderly within a given cluster are needed for a better understanding of the underlying, interacting processes. Ideally, the cluster members' health trajectories should be monitored.[29 30] This research might facilitate the development of targeted interventions and specific, preventive strategies for improving health and decreasing resource use in each cluster.

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**Data availability statement** The data analysed in the present study are the property of the sponsor (Assistance Publique - Hôpitaux de Paris) and are not publicly available. The individual participant data (IPD) analysed in this study will be made available upon reasonable request, in compliance with ICMJE guidelines. Data to be shared: de-identified individual participant data underlying the results reported in this article (including text, tables, figures and appendices). Other available documents: study protocol. Availability period: from the date of publication and up to 5 years thereafter. Eligible recipients: researchers submitting a methodologically sound proposal approved by the study sponsor (Assistance Publique - Hôpitaux de Paris). Purpose of data access: exclusively for achieving the objectives outlined in the approved proposal. Access mechanism: requests should be directed to Dr. Julien Le Breton. A data transfer agreement with the study sponsor will be required prior to granting access.

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