Who's talking? Proxy respondents' subjectivity bias in the assessment of French community-dwelling elderly's needs and unmet needs for care with daily activities

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Abstract

Proxy respondents are widely used in population health survey in order to maximise response rates. When surveys target frail elderly, the measurement error it may involve is expected to be smaller than selection or participation biases. However, in the literature on elderly needs for care, the proxy use is most often considered with a dummy variable which endogeneity with subjects' health status is rarely scrutinised in a robust way. Pitfalls from this choice address more than methodological issues. Indeed, the mismeasurement of needs for care with daily activities might lead to irrelevant social policies or private initiatives that intend to make care provision meet the needs. This paper proposes a comprehensive and tractable strategy supported by various robustness checks to cope with the suspected endogeneity of the proxy use to the unobservable subjects' health status in the report of needs for care with activities of daily living. Proxy respondents' subjectivity is thus found to inflate the needs of the elderly replaced or assisted in answering the questionnaire and to deflate the probability of unmet or undermet needs.

Key words

Proxy respondent, measurement bias, endogeneity, selection, Copula, needs for care, ADLs, IADLs

1. Introduction

Proxy respondents are widely used in order to maximise survey response rates (Bollinger and Hirsch, 2012; Bound, 1991; Graham and Jackson, 1993; Highton, 2005; Hyland et al., 1997; Reynolds and Wenger, 2012; Tamborini and Kim, 2013) and, in some extent, to objectify individual responses (Christensen and Kallestrup-Lamb, 2012; Datta Gupta and Larsen, 2010). Regarding population health survey, the use of a proxy respondent may make it possible to avoid the pitfall of questioning healthy individuals only (Santos-Eggimann et al., 1999; Shaw et al., 2000). When the surveys are aimed at documenting the health status of frail elderly, the measurement error it may involve is then expected to be smaller than selection biases (investigator's decision not to interview subjects) or participation biases (subject's denial to be interviewed) (Corder et al., 1996; Elliott et al., 2008; Kelfve et al., 2013; Shardell et al., 2012; Stineman et al., 2004; Wolinsky et al., 2016). However, this measurement bias must be controlled (Hung et al., 2007) because intrinsically not uncorrelated with either dependent (subjects' needs for care with daily activities, for instance) or independent (subjects' health status) variables (Bound et al., 2001; Grootendorst et al., 1997; Nelson et al., 1990). When available all at once, subjects' and proxies' assessments have been historically found not to be the same (Cartwright, 1957; Elinson and Trussell, 1957; Enterline and Capt, 1959), the misperception of actual subjects' health status and needs by proxies increasing with the physical distance to the subjects (Magaziner et al., 1988; Shardell et al., 2012; Snow et al., 2005; Wolinsky et al., 2014, 2011). Whilst, proxy respondents' bias in assessments of the subjects' performances and needs for assistance with activities of daily living may also be related to how they are used, as caregivers, to accessing and storing information about the observed impairments of the subjects (Hill and Pylypchuk, 2006). In this regard, they may exaggerate the deterioration of the subjects' health status or the magnitude of their needs because of their feeling of care burden (Dassel and Schmitt, 2008; Neumann et al., 2000; Perkins, 2007; Santos-Eggimann et al., 1999; Wehby et al., 2016; Zanetti et al., 1999). Nonetheless, subjects could be less subjective than proxy respondents in the assessment of their own health status and needs (Benítez-Silva et al., 2004).

In the literature on elderly health status and needs for care with daily activities, attention is rarely paid to the bias involved by the use of a proxy respondent. How self- and proxy responses may differ is not assessed because both viewpoints are not available in the same time in population surveys (Iezzoni et al., 2000). For instance, De Meijer *et al.* seem to ignore the issue when assessing the evolution in the long-term care use in the Netherlands (de Meijer et al., 2015). When addressed, the issue is most often dealt with a dummy variable (Todorov and Kirchner, 2000; Van Houtven and Norton, 2008, 2004) which contribution is unsurprisingly found to be positive. But the endogeneity of the use of a proxy respondent with subjects' health status is rarely scrutinised in a robust way, not to say never. As a result, in this positive contribution, the logical consequence of the deteriorated

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subjects' health status is hardly separable from the proxy respondents' subjectivity. Pitfalls from this choice address more than methodological issues. Indeed, the endogeneity of proxy respondent use and proxy respondent's subjectivity may dramatically distort the measurement of the actual needs for care with daily activities, thus leading to irrelevant social policies or private initiatives to meet the needs (de Meijer et al., 2015; Van Houtven and Norton, 2008, 2004).

As addressed by Angrist, 2001 regarding the general framework of the estimation of models with limited dependent variable explained, among other variables, by a dummy endogenous regressor, this paper proposes a solution to cope with the possibly joint determination of both the outcome variables (the needs for care with daily activities and how these needs are met) and what can be considered in the present case as a treatment variable (the use of a proxy-respondent) or to control for the relation between omitted variables in the model (the actual subjects' health status) and both treatment and outcome variables. In this paper, the existence and the number of needs for care with activities and instrumental activities of daily living (ADLs and IADLs respectively) are then jointly considered with the help of count models (zero inflated Poisson, due to the possibly important proportion of zeros) linked with a Copula function, due to the usual association of both kinds of needs (Lee and Kim, 2012; So et al., 2011). Identically, whether and how these needs are met with any care is modelled jointly, when needs with ADLs and IADLs are separately reported. But in both situations, the use of a proxy respondent must be especially questioned because it is suspected to be correlated with the subject's health status, which is not directly observable. Indeed, if the subject's health status is particularly impaired, a proxy respondent may be used in order to assist or even to replace the subject for the questionnaire administration. In the same time, it may also give rise to the report of needs for care with ADLs and IADLs and to the declaration of needs insufficiently met or unmet. The organisation of the paper is the following: the model, the estimation strategy contingent upon the available dataset, and the survey which the data is taken from are all presented in section 2; the statistics describing the sample, the results of the equation explaining the use of a proxy respondent, the report of needs of care with ADLs and IADLs and the declaration of unmet or undermet needs are dealt with in section 3, where the relevance of the estimation strategy is discussed in the light of the comparison with naive estimations and robustness checks are proposed; results and lessons for the assessment of elderly met and unmet needs for care are discussed at last in the conclusion.

2. Model and data

2.1 Model

In population health surveys, the health status is commonly self-assessed (Au and Johnston, 2014; Etilé and Milcent, 2006) because, among other things, it is not always possible to document the actual health status with the help of health professionals at a very large scale. This choice naturally fuels the discussion about the reliance of the health status assessment (Doiron et al., 2015). In addition, subjects may be also questioned about their ability to undertake daily activities by themselves or with the help of a third party and, when they especially report needs with care with either ADLs or IADLs, whether needs are met, unmet (Desai et al., 2001) or undermet (Lima and Allen, 2001). When the health status of the subjects prevents them from responding these questions by themselves, they are most often helped or replaced by someone supposed to know them closely. In this framework, it is quite obvious that the same unobserved phenomenon (the subject's actual health status) may explain in the same time the use of a proxy respondent, the report of needs for care and, possibly, the report of unmet or undermet needs. We address this tricky issue with the help of two series of dummy variables: the use of a proxy respondent y_1 and whether needs are met y_{3j}:

$$y_1 = 1 \text{ if } y_1^* \geq 0, y_1 = 0 \text{ if not}$$

$$y_{3j} = 1 \text{ if } y_{3j}^* \geq 0, y_{3j} = 0 \text{ if not,} \qquad \text{with } j = ADL, IADL\ .$$

Both variables are supposed to be generated by continuous latent variables y_1^* and y_{3j}^* which respectively represent the willingness to use a proxy respondent and the assessment of how needs are met:

$$y_1^* = x_1\beta_1 + h^*\delta_1 - \varepsilon_1 \tag{1}$$

$$y_{3j}^* = x_3\beta_{3j} + y_1\alpha_{3j} + h^*\delta_{3j} - \varepsilon_{3j} \qquad \text{with } j = ADL, IADL \tag{2}$$

In these equations, the x_i's represent vectors of observed individual variables , expected to be exogenous, and ε_1 and ε_{3j}'s are non-observable error terms, supposed to be independent and identically distributed according to a standardised Normal. In accordance with what has just been written, the latent variable h^* representing the subject's health status enters both equations.

Whether needs are met y_{3j}, cannot be measured directly, and the latent variable y_{3j}^* is measured only conditionally to the report of a need at least. Consequently, an equation modelling the number of needs reported for care with ADLs and IADLs must be introduced between equations (1) and (2). Obviously, the unobserved health status h^* in the two pairs of outcome variables: declaration of needs with daily activities (ADLs and IADLs) on one hand and declaration of unmet needs (ADLs and IADLs) on the other, may be correlated with the use of a proxy respondent. In addition, we must fix the count problem associated to the identification of the number needs with daily activities, due to a possibly large number of zeros, like in Lee and Kim, 2012. Recently, there has been a great emphasis in the development of econometric models dealing with the inflation of null-values in health decisions and/or healthcare consumption count data, requiring to model distinctly extensive and intensive margins (Deb and Trivedi, 1997; Gurmu and Elder, 2008, 2000; Wang, 2003). These models are all based on zero-inflated Poisson (ZIP), zero-inflated negative binomial (ZINB) models or transformations of them. In this paper, we coped with this potential pitfall with the help of a zero-inflated Poisson (ZIP) function:

$$n_{2j}\big|x_{2j} \sim \mathrm{ZIP}\left(\mu_{2j}^0, \mu_{2j}\right)$$

with:

$$P_j\left(n_{2j}=0\big|x_{2j}, h^*\right) = P_{0j} + \left(1-P_{0j}\right)\exp(-\mu_{2j})$$

$$P_j\left(n_{2j}\big|x_{2j}, h^*\right) = \left(1-P_{0j}\right)\frac{\exp\left(-\mu_{2j}\right){\mu_{2j}}^{n_{2j}}}{n_{2j}!} \text{ if } n_{2j} > 0$$

where: $P_{0j} = \left(1+e^{-\mu_{2j}^0}\right)^{-1}$

$$\mu_{2j}^0 = \exp\left(x_{2j}\beta_{2j}^0 + y_1\alpha_{2j}^0\right) \quad (3)$$

$$\mu_{2j} = \exp\left(x_{2j}\beta_{2j} + y_1\alpha_{2j} + h^*\delta_{2j}\right) \quad (4)$$

In equations (1)-(4), the latent variable h^* is the potential cause of the endogeneity of the use of a proxy respondent:

$$h^* = z\gamma - \nu \quad (5)$$

The introduction of equation (5) in equations (1)-(4) makes it possible to consider henceforth the observable variables determining the health status z and the non-observable component ν which describes the various characteristics of the health status that the subjects or the proxy respondents are not able to observe nor to depict accurately (because of, for instance, physical or psychological limitations, a limited ability to cope with illness or disabilities, emotional distress, etc.):

$$y_1^* = x_1\beta_1 + z\gamma_1 - u_1 \quad (6)$$

$$\mu_{2j} = \exp\left(x_{2j}\beta_{2j} + y_1\alpha_{2j} + z\gamma_{2j} - u_{2j}\right) \quad \text{with } j = ADL, IADL \quad (7)$$

$$y_{3j}^* = x_3\beta_{3j} + y_1\alpha_{3j} + z\gamma_{3j} - u_{3j} \quad \text{if } n_{2j} > 0 \quad \text{with } j = ADL, IADL \quad (8)$$

where y_{2j} signals the existence of needs for care or not and gives rise to the usual two-step ZIP estimation (first the probability of no need and, conditionally to the report of needs, the number of needs).

In this semi-reduced form, the error terms structure entails a common heterogeneity factor:

$$u_1 = \delta_1\,\nu + \varepsilon_1$$

$$u_{2j} = \delta_{2j}\,\nu \quad \text{with } j = ADL, IADL$$

$$u_{3j} = \delta_{3j}\,\nu + \varepsilon_{3j} \quad \text{with } j = ADL, IADL$$

where parameters δ_1, δ_{2j} and δ_{3j} represent the loading factors to be estimated.

The common non-observable factor ν actually fuels the endogeneity of the use of proxy respondent and its contribution must be controlled when estimating both reported needs for care and whether these needs are met or not. Thus, the use of a proxy respondent can be viewed as a treatment effect which endogeneity can be taken into account in several alternative ways.

The most usual is given by instrumental variables to be introduced in equation (6) and which must be correlated with the use of a respondent status but not with the error terms of equations (7), especially not with the common

factor ν. The usual identification of probit models is then based on exclusion restrictions concerning instruments introduced in the auxiliary equation and removed from equations of interest. To do so, several variables could be considered, such as the existence of children or grand-children or the number of sons and daughters. Other variables, like the living area (rural or urban) supposed to reveal family closeness as well as the availability of formal care (healthcare and personal services), are available but unfortunately not correlated with the use of a proxy respondent. Recently, Han and Vytlacil, 2017 demonstrated that, in the general framework of a two equations model with binary endogenous variables which latent error terms are jointly modelled with a copula function, an exclusion restriction is necessary and sufficient for the identification of models with no common exogenous regressors, necessary for those with common regressors, but also that identification can be achieved without exclusion restrictions when regressors are common in both equations of a multiple probit model.

Another option is to take advantage of over-identifying restrictions coming from the semi-structural model. Regarding the use of over-identifying restrictions, variables must be found, which contribute to the model made of the three equations only through their impact on the assessment of the health status h^*. It equates to consider the only variables in z not embedded in vectors x_1, x_{2j} and $x_{3j}, j = ADL, IADL$. If for instance z is made of one variable only explaining the health status h^* without entering any other equations (excluded from x_1, x_{2j} and $x_{3j}, j = ADL, IADL$), the parameters are bounded by: $\gamma_1 = \delta_1\gamma, \gamma_{2j} = \delta_{2j}\gamma, \gamma_{3j} = \delta_{3j}\gamma, j = ADL, IADL$.

Parameters δ_1, δ_{2j} and δ_{3j} can be viewed as the health status h^* impact on each latent variable in the three equations of the model. They especially enable to take into account the potential correlation between the error terms from these equations. Given the available information, normalisation restrictions must be put to make possible the identification of the parameters in the errors structure of the model. In probit models, a unit-variance is usually imposed for each error term, which consequently gives: $\delta_1 = 1$. The correlation for error terms can then be derived:

$$corr(u_j, u_s) = \frac{\delta_j \delta_s}{\sqrt{(1+\delta_j^2)(1+\delta_s^2)}}, \qquad j, s = 1,2\_ADL, 2\_IADL, 3\_ADL, 3\_IADL$$

A condition for the over-identification of each equation of interest (needs for care and whether needs are met) is also inferred for $j = ADL, IADL$:

$$\gamma_{2j} = \delta_{2j}\gamma$$

$$\gamma_{3j} = \delta_{3j}\gamma$$

It is then possible to take these conditions as assumptions enabling to check the validity of the original structural model. Non-linear restriction tests on parameters can be then computed with the help of the appropriate test-statistic and can be viewed as robustness checks of the usual option of model identification with the help of exclusion restrictions.

In addition to the endogeneity concern, attention must also be paid to the sample selection in the couple of equations (7), where the latent variable n_{2j} is defined only when a need at least has been reported by the subject or the proxy respondent. This strategy prevents from heterogeneity bias which could be substantial if ever there was no sample selection, because subjects reporting no need for care and those declaring met needs would have been put in the same class.

Yet, the strong dependence between the two count variables (number of needs reported for ADLs and IADLs) is not correctly represented by the common heterogeneity component used furthermore in order to control for selection and endogeneity biases. In this regard, a Copula function is introduced, which advantage is to keep the marginal distributions of both variables $n_{2j}, j = ADL, IADL$ expressing the number of needs for care taken from the ZIP distribution with a large number of zeros, while modelling specifically the dependence between the two categories of needs (ADLs and IADLs). The advantage of such a choice is to make possible: 1) the heterogeneity in the dispersion of the count variables, 2) the separate modelling of the high proportion of no needs for care with the two kinds of daily activities and 3) the specification of a parameter measuring the dependence level of the two count variables. This strategy is very similar to the one used by So et al., 2011 for the joint modelling of hospital stays and non-physician hospital outpatient visits of elderly Americans from the 1987–1988 National Medical Expenditure Survey or by Winkelmann, 2012 for the joint modelling of the insurance decision and ambulatory care consumption.

Copula theory and its applications in econometrics have been detailed in Trivedi and Zimmer, 2007. Just remind that the copula function relies the joint distribution function of the count variables to the marginal distributions:

$$F\left(n_{2\_ADL}, n_{2\_IADL}\right) = C_\theta\left(F_{ADL}\left(n_{2\_ADL}\middle|x_{2\_ADL}, v\right), F_{IADL}\left(n_{2\_IADL}\middle|x_{2\_IADL}, v\right)\right)$$

with:

$$F_j\left(n_{2j}\middle|x_{2j}, v\right) = \sum_{s=0}^{n_{2j}} P_j\left(s\middle|x_{2j}, v\right)$$

for $j = ADL, IADL$ and θ represents the dependence parameter between n_{2_ADL} and n_{2_IADL}.

Two alternative specifications for the copula function may be considered:

Clayton's copula: $C_\theta(u_1, u_2) = \left(u_1^{-\theta} + u_2^{-\theta} - 1\right)^{-\frac{1}{\theta}}$ with $\theta \geq 0$ as only possible dependence,

Franck's copula: $C_\theta(u_1, u_2) = -\theta^{-1} log\left[1 + \frac{\left(e^{-\theta u_1} - 1\right)\left(e^{-\theta u_2} - 1\right)}{e^{-\theta} - 1}\right]$ with $-\infty < \theta < \infty$.

which relevant use must be based on the basis of an information criteria such as BIC.

Copulas may be used in order to model either the joint distribution of the selection index and the structural error as an alternative to Heckman modelling (Smith, 2003) or a dichotomous dependent variable and binary endogenous explanatory variables without the joint normality assumption (Winkelmann, 2012) in a bivariate probit framework (Keay, 2016). Our model may look like the ones considered by Winkelman, Smith or Keay consisting in bivariate probits: two equations modelling the outcome variables (the needs reported in the first equation, the needs met or unmet in the second one) where the first equation contributes also to sample selection but, in addition, our model entails the estimation of a dummy variable (the use of proxy respondent) suspected to be endogenous with the subject's health status that does also explain the report of needs and unmet needs for care with daily activities.

At last, our model is, in part, quite close to the one of Bratti and Miranda, 2011, where a binary endogenous variable, considered as a treatment variable (regarding our paper, the use of a proxy-respondent), may influence the outcome variable which takes the form a count variable. This is, in part only the same framework because, first, this count equation regarding needs for care with ADLs is in our model related to another similar one concerning needs with IADLs through a copula function and, second, those two count equations act as selection equations for the estimation of whether these needs are met or not. As in their paper, we suppose that whether elderly do have any need with ADLs and/or IADLs (the extensive margin) and the number of their needs (the intensive margin) are determined by two distinct processes required by the magnitude of null values. With no attention paid to selection, estimates may present a heterogeneity bias due to the mixture, in the subsample of individuals with null values: those whose needs for care are all met and those with no need. Kim, 2006 proposed also a three-equation model very close to ours, where a dummy variable may be endogenous in both the selection and the censored equation. The main difference is that we propose a couple of selection equations linked by a copula function, because of the obvious relationship between needs for care with ADLs and IADLs, and a couple of censored equations.

2.2 Data

The equations (6)-(8) are estimated with the help of the data from the French national representative survey on disability and health (Handicap-Santé Ménages – HSM survey) carried out by the French National Institute of Statistics (INSEE) and the Ministry of Health (Direction de la Recherche, de l'Evaluation, des Etudes et des Statistiques - DREES) and which concerned about 30,000 individuals living in the community (see Bouvier, 2011; Bussière et al., 2016; Renaut, 2012 for a description). Data have been collected with a standardized questionnaire administered in face-to-face interviews, which covers medical information (diseases, impairments, functional limitations, restrictions of activity, healthcare use), as well as socioeconomic characteristics (household composition, educational level, income) and a description of the environment (home layout and facilities, assistive devices). Depending on the ability of subjects to answer the questionnaire by themselves, responses were self-, proxy-assisted or proxy responses. Formal and informal care, if any, provided by professionals and relatives were also recorded. The survey has been approved by the French Commission on Information Technology and Liberties (decision CE2008-721). It concerned 4,580 elderly aged 75 and older living in the community.

The need for care with daily activities is defined with the answers to three successive questions. First, subjects and/or their proxy were asked about their ability to perform daily activities. If they reported not to be able to do a given activity without help or to be able to do it but with a lot of difficulties[1], they were considered as needing care in order to realise the activity. If so, secondly, they were asked whether they actually got assistance for the realisation of the activity. Then, thirdly, if not they did not receive any help, the need for care was declared unmet; if they received assistance, but not sufficiently (subjects and/or proxies reporting needing more assistance), the need was declared undermet; if the assistance was enough (no remaining need), the need was declared met.

The ADLs retained in this paper are given by the seven most popular used in the literature (Katz et al., 1963): bathing (or showering), dressing, using the toilet, transferring, eating, moving inside (or walking), fecal and urinary elimination. Eight IADLs are also considered, among the ones previously defined by Lawton and Brody, 1969: shopping, housework, cooking, managing money, use of transports, taking medications, use of the phone, and communication[2].

The regressors set in equations (6)-(8) is restricted to the most common variables considered in the literature documenting the existence of needs and unmet needs: the subjects' age (75-79, 80-84, 85 and older), gender, composition of the household (alone, with spouse only, other), education (no degree, less than A-level, A-level and higher), income (quartiles), self-assessed health status (very good or good, fairly good, bad or very bad) and living area (rural, urban). Following the behavioural model developed by Andersen and Newman (Andersen and Newman, 1973; Andersen, 1995), these variables are predisposing (gender, age, education), enabling (income) and need (self-assessed health status) factors expected to be associated with the declaration of needs and, potentially, unmet needs. The place where the subject lived is usually viewed as an indirect measure of the potential supply for home care (Clark and Dellasega, 1998). When a proxy respondent has been involved in the administration of the questionnaire, her closeness with the subject has been documented (spouse, child, other). Three variables in the dataset were found associated with the use of a proxy and not associated with the report of needs and unmet/undermet needs: meetings with friends in the last month, meetings with family in the last month, and the proportion of daughters in the progeny. As a result, they have been used as instruments for the use of a proxy respondent in order to ensure the identification of equations (7)-(8).

3. Results

3.1 Sample characteristics

In the HSM survey, more than one elderly aged 75 years and older out of four has been assisted or replaced by a proxy respondent for the completion of the questionnaire. The composition of proxy respondents makes room substantially for spouses, compared to the distribution of informal caregivers in the US Health and Retirement Survey for instance (made of children by about three-quarters and other people by about one-quarter)(Groneck, 2017). Unsurprisingly, the main informal caregivers and, as a result, the preferred proxy-respondents, are the cohabiting ones (spouses or children).

Self-respondents and respondents assisted with a proxy exhibit statistically significant differences in age (oldest old are more numerous among respondents assisted with a proxy), gender (self-respondents are more frequently female), household composition (self- live more often alone or with a spouse), education (self- declared higher degrees than assisted respondents) and self-assessed health status (unsurprisingly, assisted respondents declared worsened health statuses). No difference can be found in the same time regarding income nor living area (Table 1). There is also an important heterogeneity among the respondents assisted with a proxy. Except for the living area, their main characteristics may indeed strongly differ. Hence, those whose spouse helped or even replaced them to answer the questionnaire were younger and more often male than respondents who asked a child or another person to help or replace them when answering the questionnaire. They lived naturally more frequently with spouse and seemed to have higher degrees. They also distributed quite equally among the various income categories and they reported worse health status.

[1] Alternative definitions of the need for care were used. In what follows, the definition is stricter than considering that a need exists when the subject cannot perform the activity without help or is able to do it but with a lot of difficulties. Intuitively, this restricted definition enables to identify a smaller prevalence for needs and, possibly, unmet or undermet needs. However, the general thrust of the results presented in the next section remains the same if ever the needs are defined in much broader way (tables are not reproduced in the paper), which contributes to their robustness.

[2] Once again, the inclusion of additional daily activities does not distort the results.

Table 1. Sample statistics.

Variables		Proxy respondents				Self respondents	Total	p-value[1]	p-value[2]
		Spouse (n = 455)	Child (n = 571)	Other (n = 224)	Total (n = 1250)	(n = 3330)	(n = 4580)		
Age	*75-79*	39,8	22,6	18,8	28,2	47,2	42	<0,0001	<0,0001
	80-84	36	23,6	32,1	29,6	32,1	31,4		
	85+	24,2	53,8	49,1	42,2	20,7	26,6		
Gender	*Male*	66,8	20,3	28,6	38,7	35	36	<0,0001	<0,0001
	Female	33,2	79,7	71,4	61,3	65	64		
Household	*Alone*		35,7	52,7	40,5	46,8	41,1	<0,0001	<0,0001
	With spouse only	88,4	13,5	9,8	40,1	42	41,5		
	Other	11,6	50,8	37,5	34,1	12,2	17,4		
Education	*No degree*	44,4	58,7	63,8	54,4	35,7	40,8	<0,0001	<0,0001
	< A-levels	45,9	38,3	30,4	39,7	52,4	48,9		
	≥ A-levels	9,7	3	5,8	5,9	11,9	10,3		
Income	*1st quartile*	22,9	28,7	37	28,1	28,2	28,2	0,0078	0,3710
	2nd quartile	27,5	28,4	23,7	27,2	26,4	26,6		
	3rd quartile	28,1	23,5	24,1	25,3	23,8	24,2		
	4th quartile	21,5	19,4	15,2	19,4	21,6	21		
Reported health status	*Very good or good*	6,4	11	9,8	9,1	18,1	15,7	0,0286	<0,0001
	Fairly good	26,8	28,6	33	28,7	40,7	37,4		
	Bad or very bad	66,8	60,4	57,1	62,1	41,1	46,9		
Area	*Rural*	27,7	23,8	27,2	25,8	23,6	24,2	0,3201	0,1167
	Urban	72,3	76,2	72,8	74,2	76,4	75,8		

[1] Chi-square test p-value (null: no difference in the distribution of variables within proxy respondents categories)

[2] Chi-square test p-value (null: no difference in the distribution of variables between proxy and self-respondents)

The prevalence of needs for care with ADLs and IADLs is obviously not the same, comparing self- and assisted respondents (Table 2). The sharp difference in the mean numbers of the reported needs with ADLs (0.26 compared to 2.17) is strongly significant. Furthermore, the proportion of elderly with no needs are important in both categories, but obviously more regarding self-respondents (85.7% compared to 41.9%). In the same time, differences among the assisted respondents are much more negligible and non-statistically significant. Regarding IADLs, the findings are slightly different. There is still an important and statistically significant gap in the mean numbers of needs with IADLs that the elderly reported (1.06 versus 4.34), but the proportions of null values, although significantly different (64.4% versus 20.2%), are smaller than the ones concerning ADLs. These results are for instance in line with the ones of Magaziner et al., 1988, which stated that the disagreement between self- and proxy respondents is especially higher for IADLs than for ADLs.

In addition, the assisted respondents seemed significantly more heterogenous regarding needs with IADLs, the ones helped by their spouse being at smaller probabilities to need care than the others. Reminding the scope of IADLs, one may question the potential influence of the living habits and the distribution of household chores which may mitigate the magnitude of the care that the assisted respondents actually receive but are not aware of. Contrary to Neumann et al., 2000 or Shaw et al., 2000 and like in Magaziner et al., 1988, the proxy respondents supposed to have much more numerous contacts with the subjects they helped or replaced in answering the questionnaire (spouses compared to children or other proxies) did not report significantly higher needs for care.

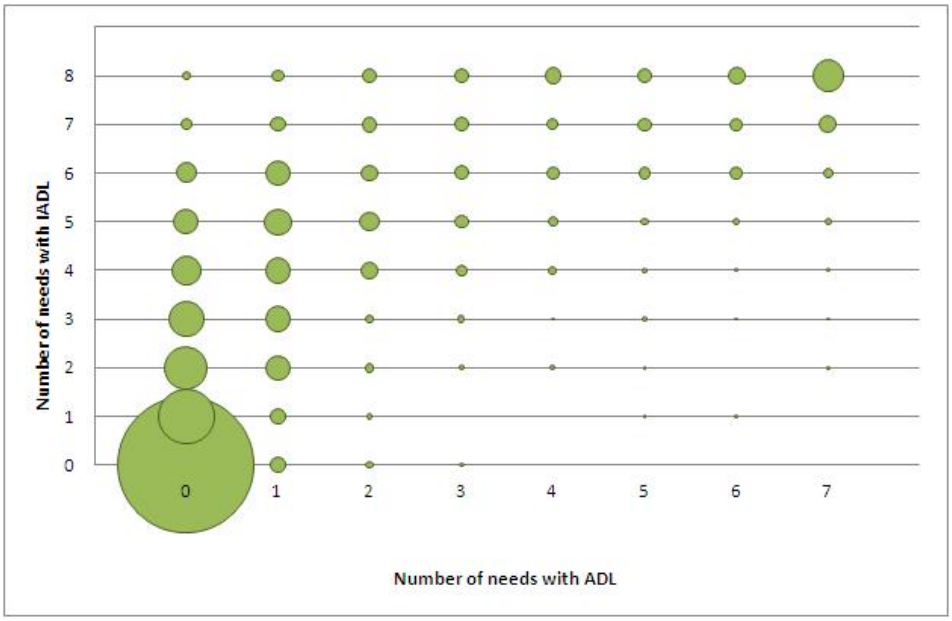
The report of ADLs seems, moreover, to go hand in hand with the one of IADLs. Figure 1 first reveals an important accumulation of simultaneous null values for the reported needs with ADLs and IADLs that must be taken into account when modelling the number of needs reported by the elderly. Secondly, it stresses that the declaration of needs with one kind of daily activities (ADLs or IADLs) is rarely separated from the report of needs with daily activities of the other kind. This is especially true concerning the report of needs with IADLs conditionally to the report of needs for care with one ADL at least. This finding must also be considered when modelling the declaration of needs for care with ADLs and IADLs with the help of an explicit dependence parameter in a copula function.

Table 2. Number of needs with ADL and IADL (% and mean).

	Proxy respondents				Self respondents	Total	p-value[1]	p-value[2]
	Spouse (n = 455)	Child (n = 571)	Other (n = 224)	Total (n = 1250)	(n = 3330)	(n = 4580)		
ADL								
0	46,8	38,5	40,6	41,9	85,7	73,8	0,2476	<0,0001
1	13,6	16,3	17,9	15,6	8,9	10,7		
2	6,6	10,2	10,3	8,9	2,4	4,2		
3	5,7	6	5,8	5,9	1,3	2,5		
4	3,3	5,6	4,9	4,6	0,9	1,9		
5	5,3	4,5	2,7	4,5	0,4	1,5		
6	6,1	5,1	6,2	5,7	0,2	1,7		
7	12,6	13,8	11,6	13,0	0,2	3,7		
Mean	2,08	2,27	2,07	2,17	0,26	0,78	0,4377	<0,0001
IADL								
0	28,4	13,8	19,6	20,2	64,4	52,2	0,0002	<0,0001
1	5,5	6,8	8,5	6,6	10,4	9,4		
2	5,5	7	3,6	5,8	7,1	6,8		
3	5	7,4	7,1	6,5	5,1	5,5		
4	6,6	7,9	7,6	7,4	4,6	5,3		
5	8,1	9,5	8	8,7	4,4	5,6		
6	11	11,6	15,6	12,1	2,7	5,3		
7	9	13,3	10,7	11,3	1	3,8		
8	20,9	22,7	19,3	21,4	0,3	6,1		
Mean	3,95	4,66	4,3	4,34	1,06	1,96	0,0007	<0,0001

[1] Chi-square (%)/ANOVA (mean) test p-value (null: no difference in the distribution of variables within proxy respondents categories)
[2] Chi-square (%)/ANOVA (mean) test p-value (null: no difference in the distribution of variables between proxy and self-respondents)

Figure 1. Needs with ADLs and IADLs among people aged 75 years and older.



Differences in the prevalence of unmet and undermet needs are also statistically significant between self- and assisted respondents (Table 3). 31.8% (respectively 35.7%) of the self- and 39.8% (respectively 45.5%) of the assisted respondents reported that they got no assistance or insufficient assistance although they reported needs with ADLs (respectively with IADLs). Nevertheless, the discrepancies among the assisted respondents are not strong enough to be statistically significant even if, concerning both ADLs and IADLs, respondents assisted by their spouse or helped by a person other than a relative revealed substantially different. Bringing together findings in Tables 2 and 3, we may figure out that the elderly who relied on their spouse to answer the questionnaire reported at best as many needs as the respondents assisted by a person not being a relative, but

they also declared higher difficulties to have their needs met, which suggests that they are likely to be both less self-sufficient and more frail in their daily living (Santos-Eggimann and Sirven, 2016).

Table 3. Unmet and undermet needs with ADLs and IADLs among the elderly needing care.

	Proxy respondents				Self respondents	Total	p-value[1]	p-value[2]
	Spouse	Child	Other	Total				
ADL	41,3	41,3	33,1	39,8	31,8	36,6	0,2177	0,0184
IADL	47,2	45,9	41,1	45,5	35,7	40,2	0,5110	0,0033

[1] Chi-square test p-value (null: no difference in the distribution of variables within proxy respondents categories)
[2] Chi-square test p-value (null: no difference in the distribution of variables between proxy and self-respondents)

These findings are consistent with the ones of Khatutsky et al., 2006 concerning the differences in the numbers of needs for care with ADLs and IADLs. Of course, the absolute values are not the same ones, because they may rely on different definitions of the needs and characteristics of the sample, but the sign of the difference in needs with ADLs and IADLs between self- and assisted respondents is the same. In contrast, respondents assisted by proxies reported in the paper by Khatutsky et al., 2006 slightly lower unmet needs than self-respondents, without that difference with our results being made more explicit.

3.2 Recursive estimation of the model

The use of a proxy respondent (equation (6)) is positively and significantly related to the age of the subject, more frequent when the subject is a man and not living alone (Table 4). Low education levels are also positively associated with the use of a proxy respondent and a bad self-assessed health status. Unsurprisingly, the subjects who rated their health status as neither good nor very good relied significantly more often on a proxy. Last, those with a low income (less than the first quartile) had a smaller probability to use a proxy. Two of the three instruments for the use of a proxy respondent signalling social and family integration (whether friends have been met in the last month and the frequency of family visits) are negatively correlated to it; the proportion of daughters in the lineage is, on the contrary, positively linked to the use of a proxy. These three variables are used as predictors of the proxy use with the other covariates of equation (6) in order explain the declaration of needs for care with ADLs and IADLs (equations (7_ADL) and (7_IADL) respectively) and, conditionally to the report of needs, the existence of any unmet or undermet need with ADLs and IADLs (equations (8_ADL) and (8_IADL) respectively).

Table 4. Estimation of the recursive model with Franck copula: equation (6)

Regressors		Use of proxy respondent	
		Coeff	Std Err
Age	*75-79*	ref	-
	80-84	0,421***	0,073
	85+	1,158***	0,075
Gender	*Male*	0,178***	0,067
	Female	ref	-
Household	*Alone*	ref	-
	With spouse only	0,577***	0,075
	Other	1,302***	0,084
Education	*No degree*	0,937***	0,128
	< A-levels	0,398***	0,122
	≥ A-levels	ref	-
Income	*1st quartile*	-0,257***	0,098
	2nd quartile	-0,075	0,096
	3rd quartile	-0,019	0,096
	4th quartile	ref	-
Reported health status	*Very good or good*	ref	-
	Fairly good	0,216**	0,100
	Bad or very bad	0,759***	0,096
Area	*Rural*	0,112	0,070
	Urban	ref	-
Instruments	*Friends met last month*	-0,232***	0,059
	Frequent meetings with family	-0,176***	0,061
	Proportion of daughters	0,316***	0,079
Constant		-2,902***	0,154

Table 4 (continued). Estimation of the recursive model with Franck copula: equations (7_ADL)-(8_ADL)

Regressors		Equation (7_ADL) No need with ADL		Equation (7_ADL) Number of needs with ADL		Equation (8_ADL) Unmet need with ADL	
		Coeff	Std Err	Coeff	Std Err	Coeff	Std Err
Age	*75-79*	ref	-	ref	-	ref	-
	80-84	-0,232**	0,108	0,213***	0,060	0,816***	0,303
	85+	-0,781***	0,112	0,442***	0,061	1,190***	0,379
Gender	*Male*	0,581***	0,101	0,052	0,052	0,491**	0,252
	Female	ref	-	ref	-	ref	-
Household	*Alone*	ref	-	ref	-	ref	-
	With spouse only	0,260**	0,126	0,247***	0,071	0,692**	0,310
	Other	-0,063	0,123	0,541***	0,062	1,615***	0,459
Education	*No degree*	0,079	0,202	0,402***	0,110	1,258**	0,523
	< A-levels	-0,161	0,196	0,322***	0,107	0,512	0,436
	≥ A-levels	ref	-	ref	-	ref	-
Income	*1st quartile*	0,006	0,140	-0,058	0,068	-0,189	0,300
	2nd quartile	-0,079	0,143	-0,168**	0,069	0,067	0,293
	3rd quartile	0,013	0,139	-0,021	0,066	-0,036	0,292
	4th quartile	ref	-	ref	-	ref	-
Reported health status	*Very good or good*	ref	-	ref	-	ref	-
	Fairly good	-0,901***	0,187	0,071	0,125	-0,300	0,461
	Bad or very bad	-1,741***	0,176	0,717***	0,118	1,213**	0,526
Area	*Rural*	0,112	0,099	0,140***	0,048	-0,320	0,225
	Urban	ref	-	ref	-	ref	-
Proxy respondent	*Spouse*	-1,431***	0,140	0,517***	0,084	-2,496***	0,715
	Child	-1,224***	0,131	0,385***	0,076	-2,320***	0,663
	Other	-1,212***	0,170	0,439***	0,089	-2,743***	0,781
	Self respondent	ref	-	ref	-	ref	-
Constant		2,379***	0,264	-1,033***	0,174	-3,621***	1,014

Table 4 (continued). Estimation of the recursive model with Franck copula: equations (7_IADL)-(8_IADL)

Regressors		Equation (7_IADL) No need with IADL		Equation (7_IADL) Number of needs with IADL		Equation (8_IADL) Unmet need with IADL	
		Coeff	Std Err	Coeff	Std Err	Coeff	Std Err
Age	*75-79*	ref	-	ref	-	ref	-
	80-84	-0,300***	0,084	0,154***	0,029	0,222**	0,104
	85+	-0,980***	0,095	0,302***	0,029	0,384***	0,109
Gender	*Male*	0,787***	0,082	-0,012	0,026	0,125	0,098
	Female	ref	-	ref	-	ref	-
Household	*Alone*	ref	-	ref	-	ref	-
	With spouse only	0,419***	0,089	0,051	0,032	0,269**	0,113
	Other	0,071	0,110	0,202***	0,030	0,504***	0,121
Education	*No degree*	-0,109	0,152	0,118**	0,052	0,600***	0,190
	< A-levels	-0,238*	0,142	0,074	0,050	0,266	0,178
	≥ A-levels	ref	-	ref	-	ref	-
Income	*1st quartile*	0,081	0,119	0,005	0,034	-0,016	0,133
	2nd quartile	0,002	0,117	-0,032	0,034	-0,079	0,130
	3rd quartile	-0,004	0,117	0,008	0,034	0,017	0,131
	4th quartile	ref	-	ref	-	ref	-
Reported health status	*Very good or good*	ref	-	ref	-	ref	-
	Fairly good	-0,937***	0,124	0,072	0,053	-0,011	0,177
	Bad or very bad	-2,119***	0,124	0,331***	0,050	0,482***	0,172
Area	*Rural*	-0,099	0,084	0,061**	0,024	-0,146	0,094
	Urban	ref	-	ref	-	ref	-
Proxy respondent	*Spouse*	-1,643***	0,127	0,431***	0,041	-1,069***	0,175
	Child	-1,819***	0,140	0,357***	0,037	-1,002***	0,155
	Other	-1,461***	0,189	0,347***	0,045	-1,196***	0,193
	Self respondent	ref	-	ref	-	ref	-
Constant		1,800***	0,174	0,546***	0,072	-1,202***	0,252

*,**,*** : statistical significance at 0.1, 0.05, 0.01 level

The contribution of the regressors of the needs for care with ADLs and IADLs usually considered within the framework of the Andersen and Newman behavioural model is globally the one expected (Bruni and Ugolini, 2016; Calsyn and Winter, 2001; Davin et al., 2009, 2005). The two-step estimation strategy related to the ZIP model used in this paper (reporting no need as a first step and conditionally to the report of one need at least, estimating the number of needs) mainly enables to decompose the statistically significant contribution of the regressors as a negative one regarding the report of no need with ADLs (higher age groups, bad self-assessed health status) and IADLs (the same variables plus an education level less than A) and a positive one concerning

the number of needs both reported with ADLs and IADLs (equations (7_ADL) and (7_IADL)). The same variables as the ones considered in the report of strictly positive numbers of needs are implied in the declaration of unmet or undermet needs, conditionally to the previous report of needs with either ADLs or IADLs. Thereon, needs are all the more likely not to be met (unmet or undermet) that subjects are among the oldest old, male (for ADLs only), not living alone, without any degree and not declared healthy by themselves (equations (8_ADL) and (8_IADL)).

The estimated values of the parameters δ (Table 5) unambiguously support the endogeneity of the use of a proxy respondent with the unobserved subject's health status, in the equations of both needs ($\delta_{2j}, j = ADL, IADL$) and unmet/undermet needs ($\delta_{3j}, j = ADL, IADL$), the null hypothesis of nullity of the parameters δ being systematically and strongly rejected. Second, the positive signs of the parameters δ suggest that the contribution of the proxy dummy would be overstated if the endogeneity was not controlled. In other words, the consideration of the endogeneity issue seems to assist in disentangling the pure contribution of the proxy respondent's subjectivity from the reasons of her assistance that can be reduced to the subject's health status.

Table 5. Estimation of the recursive model with Franck copula: specification test statistics

Parameters	ADL		IADL	
	Coeff	Std Err	Coeff	Std Err
δ_1	1	-	1	-
δ_2	0,449***	0,044	0,167***	0,020
δ_3	2,770***	0,706	1,208***	0,117
θ	7,368***		0,240	

*,**,*** : statistical significance at 0.1, 0.05, 0.01 level

Moreover, the formal link between the declaration of needs and unmet/undermet needs with ADLs on one hand and with IADLs on the other, that has been marked explicitly with the help of Franck's copula function, is found relevant. Parameter θ is indeed significantly positive, in line with what could be expected following the Figure 1.[3]

Last, the analysis of the estimated correlation parameters of the error terms in equations (6)-(8) highlights a positive structure backed by the values of the δ parameters previously estimated (Table 6). Besides, two results are of particular interest: 1) the error term taken from the proxy use equation is very positively correlated to the error term in the report of needs and unmet/undermet needs equations; 2) although weaker, the value and the statistic significance of the correlation parameters $corr(u_{2\_ADL}, u_{3\_ADL})$ and $corr(u_{2\_IADL}, u_{3\_IADL})$ state that the omitted variables in (7) are positively correlated with the ones in (8) and justify the use of a sample selection between equations (7) and (8), conditioning the estimation of unmet/undermet needs to the primary report of a need for care with daily activities.

Table 6. Correlation estimates of error terms of equations (6)-(8).

	Coeff	Std Err
$corr(u_1, u_{2\_ADL})$	0.4224***	0.0335
$corr(u_1, u_{2\_IADL})$	0.1728***	0.0190
$corr(u_1, u_{3\_ADL})$	0.9404***	0.0149
$corr(u_1, u_{3\_IADL})$	0.7688***	0.0299
$corr(u_{2\_ADL}, u_{3\_ADL})$	0.3973***	0.0301
$corr(u_{2\_IADL}, u_{3\_IADL})$	0.1328***	0.0146
$corr(u_{2\_ADL}, u_{3\_IADL})$	0.3248***	0.0258
$corr(u_{2\_IADL}, u_{3\_ADL})$	0.1625***	0.0175

*,**,*** : statistical significance at 0.1, 0.05, 0.01 level

Alternatively to the use of instruments for the model identification purpose, the use of over-identifying restrictions has been suggested above, concerning the parameters $\gamma_{2j} = \delta_{2j}\gamma$ and $\gamma_{3j} = \delta_{3j}\gamma, j = ADL, IADL$ where γ is the parameter associated to the observable variables z assumed to explain the latent variable h^*. The F-statistic for the null hypothesis based on the eight restrictions relating the γ's to the δ's[4] is given by $F = \frac{(SSR_c - SSR_u)/r}{SSR_u/(n-k)} = \frac{(14369{,}59 - 14328{,}67)/8}{14328{,}67/(4580-12)} = 1{,}5950$ which *p-value* is equal to 0,1207. It is then not possible to reject

[3] The use of the Clayton's copula led to similar results. The estimation of parameter θ is in this case equal to 3.574, with a standard error equal to 0.171. Like in So et al., 2011, the Franck's copula has been preferred on the basis of the usual information criteria (AIC and BIC).

[4] The restrictions on γ_2 and γ_3 are computed separately for ADLs and IADLs and distinguish individuals whose self-assessed health status is either good/very good or fair/bad/very bad.

the null hypothesis made by the overidentifying restrictions, thus supporting the validity of the original semi-structural model.

Concerning more especially the use of a proxy respondent, the results stress differentiated contributions, depending on the report of needs or the report of unmet/undermet ones. Then, the report of a strictly positive number of needs for care with both ADLs and IADLs is positively and significantly explained by the use of a proxy respondent (equations (7_ADL) and (7_IADL)). This finding supports the idea that the proxy use would inflate the declaration of needs, like in previous studies (Desai et al., 2001; Lima and Allen, 2001; Todorov and Kirchner, 2000) although, unlike these papers, the endogeneity of the proxy use with the health status has been controlled in ours. In this regard, Table 7 in the sub-section 3.3 below will be useful to state the sign and the magnitude of the bias that the estimation strategy developed in this paper enables to prevent. Since the proxy respondents are most often the caregivers also, they can be supposed to overstate needs compared to the ones that elderly would have declared by themselves (Ball et al., 2001; Dorevitch et al., 1992; Rothman et al., 1991) and to bring out both the health and disability status of the surveyed person (Epstein et al., 1989; Iezzoni et al., 2000) and their role of caregiver (Bandayrel and Johnston, 2014; Neumann et al., 2000; Roydhouse and Wilson, 2017). Whilst, being assisted or replaced by a proxy respondent strongly and significantly reduces the probability to declare unmet or undermet needs (equations (8_ADL) and (8_IADL)). Like in Desai et al., 2001, these results support the view that the proxy respondents may have given value to the assistance they are likely to have done, in opposition to the view that the burden of care (caregivers are found to develop morbidities and depressive symptomatology due to caregiving) affects carers' ability to cope with the needs addressed by the elderly (Hsu et al., 2017; Long et al., 1998).

3.3 Comparison of naive and recursive estimations

The Table 7 compares the parameters associated to the proxy dummies estimated with the help of simple probit equations and the ones we got with our recursive model made of equations (6)-(8). It also distinguishes the results according the distinct or the joint consideration of ADLs and IADLs. It first reveals that the control for the endogeneity of the dummy assumed to signal the use of a proxy respondent does not distort significantly its negative contribution to the absence of declaration of any need with ADLs or IADLs when a Franck's copula is used (equation (7), no need). This observation is slightly modified but still holds when ADLs and IADLs are jointly considered. In contrast, the control for endogeneity reduces the contribution to the number of reported needs with ADLs and, in a less extent, IADLs (equation (7), number of needs). The result is strenghtened when ADLs and IADLs are not distinguished. Thus, the dummy signalling the use of a proxy respondent still explains the declaration of needs and the number of needs reported even when the endogeneity of the dummy is taken into account. This finding supports that, independently from all the arguments related, among others, to the unobservable subjects' health status justifying their use, proxy respondents demonstrates subjectivity by overstating needs.

Table 7. Proxy parameters estimates in simple and recursive models.

	ADL and IADL distinct				ADL and IADL joint	
	Simple models		Recursive model with copula		Simple models	Recursive model
	ADL	IADL	ADL	IADL		
Equation (7) (no need)						
Proxy – spouse	-1,193***	-1,070***	-1,431***	-1,643***	-1,064***	-1,628***
Proxy – child	-1,073***	-1,177***	-1,224***	-1,819***	-1,169***	-1,913***
Proxy – other	-1,077***	-0,956***	-1,212***	-1,461***	-1,001***	-1,589***
Proxy-total	**-1,119*** **	**-1,089*** **	**-1,309*** **	**-1,674*** **	**-1,092*** **	**-1,725*** **
Equation (7) (number of needs)						
Proxy – spouse	1,021***	0,666***	0,517***	0,431***	0,903***	0,189***
Proxy – child	0,957***	0,560***	0,385***	0,357***	0,750***	0,034
Proxy – other	0,929***	0,562***	0,439***	0,347***	0,752***	0,0319
Proxy-total	**0,967*** **	**0,594*** **	**0,438*** **	**0,382*** **	**0,801*** **	**0,082** **
Equation (8) (unmet need)						
Proxy – spouse	0,127	0,231**	-2,496***	-1,069***	0,254***	-0,251**
Proxy – child	0,217**	0,263***	-2,320***	-1,002***	0,336***	-0,167*
Proxy – other	0,042	0,147	-2,743***	-1,196***	0,140	-0,379***
Proxy-total	**0,153***	**0,230*** **	**-2,420*** **	**-1,066*** **	**0,271*** **	**-0,232*** **

*,**,*** : statistical significance at 0.1, 0.05, 0.01 level

The differences in the results concerning the unmet/undermet needs are much more challenging (equation (8)). As a matter of fact, the proxy use is found to deflate the declaration of unmet/undermet needs whereas it would have inflated it if the dummy endogenity has not been controlled. The reversal of the sign of the estimated

parameter associated to the endogenous dummy is meaningful. Admittedly, Desai et al., 2001, Lima and Allen, 2001 and Long et al., 1998 concluded, in other countries and time periods than ours, to similar results. But their results relied on the logit estimation of a single equation where the use of a proxy respondent is simply indicated by a dummy variable and with no specific attention to the endogeneity issue. In addition, their samples were at once restricted to elderly who reported needs only, which ignored the common factors which may both explain whether elderly reported needs and whether these needs were met or not.

3.4 Marginal effects

The marginal effects concerning the contributions of the covariates in equations (6)-(8) are nonlinear functions of the parameter estimates (Table 8). The delta method has been used to get a linear approximation of the standard errors (Greene, 2012). If the closeness of the proxy with the subject is not questioned, being helped or replaced by a proxy respondent reduces the probability to declare no need with ADLs by 0.43 (respectively by 0.55 with IADL). It adds 0.58 need for care with ADLs and 2.01 needs with IADLs and reduces the probability to report unmet/undermet needs with ADLs by 0.10 (respectively by 0.30 for unmet/undermet needs with IADLs). Distinguishing the proxies according their privacy with the elderly they helped or replaced in responding the questionnaire reveals an upward gradation, although not statistically significant, in the intensity of the marginal effects in equations (7_ADL) and (7_IADL) but not in equations (8_ADL) and (8_IADL). Thus, there would be no expectation to carry in our dataset about the identification of the proxy closeness, unlike what was found in Elliott et al., 2008, Magaziner et al., 1988, Santos-Eggimann et al., 1999 or Wolinsky et al., 2016 for instance[5] where the overestimation of needs with ADLs and/or IADLs was mainly from close relatives.

Table 8. Marginal effects associated with proxy respondents parameters (average individual).

		Equation (7_ADL)				**Equation (8_ADL)**	
		No needs		**Number of needs**		**Unmet/undermet needs**	
Proxy		Coeff	Std Err	Coeff	Std Err	Coeff	Std Err
	Spouse	**-0.4730*** **	0.0487	**0.7131*** **	0.0803	**-0.1119***	0.0571
	Child	**-0.3912*** **	0.0466	**0.5194*** **	0.0620	**-0.1118****	0.0569
	Other	**-0.3862*** **	0.0634	**0.5563*** **	0.0837	**-0.1120***	0.0573
	Total	**-0.4264*** **	0.0324	**0.5823*** **	0.0551	**-0.1039*** **	0.0359
		Equation (7_IADL)				**Equation (8_IADL)**	
		No needs		**Number of needs**		**Unmet/undermet needs**	
Proxy		Coeff	Std Err	Coeff	Std Err	Coeff	Std Err
	Spouse	**-0.5501*** **	0.0274	**2.1606*** **	0.1485	**-0.3088*** **	0.0365
	Child	**-0.5794*** **	0.0255	**2.0430*** **	0.1340	**-0.2969*** **	0.0345
	Other	**-0.5123*** **	0.0452	**1.7701*** **	0.1826	**-0.3284*** **	0.0344
	Total	**-0.5549*** **	0.0215	**2.0059*** **	0.1068	**-0.3020*** **	0.0314

*,**,*** : statistical significance at 0.1, 0.05, 0.01 level

4. Conclusion

Population health surveys face the challenge of documenting the population health status at a very large scale. The quality of health data can actually suffer from the way they are collected, jeopardizing the use that both researchers and public health policy decision-makers will be able to do with. To prevent the risk of questionning only healthy people and to avoid too numerous missing data, a usual option of these population surveys is to appeal to proxy respondents who help or even replace people with particularly poor health status in their answers. The choice of a proxy respondent entails potential perception errors about health status, functional and cognitive limitations, impairments and disabilities that the literature has widely reported. It also raises obvious endogeneity problems that, in the context of the report of both needs and unmet-undermet needs with daily activities, the paper proposed to solve. It was based on a convenient and tractable model made of three equations recursively estimated and enabling for: 1) a double endogeneity control of the use of a proxy respondent with the unobserved health status of the elderly assisted or replaced in answering the questionnaire, 2) sample selection in the estimation for unmet/undermet needs conditionally to the report of needs and 3) the consideration of the association of ADLs and IADLs in the usual process of autonomy loss. That estimation strategy contributed to disentangle proxy respondents' own sensitivity and subjectivity from objective motives

[5] The marginal effects computed for the median individual (a woman, aged more than 74 years and less than 80, living alone in a urban area, with a A-level at least, an income higher than Q_3 and reporting a good to very good health status) with no distinction regarding the proxy closeness to the subject were oriented globally in the same way. Using a proxy reduces by 0.13 (p=0.017) the probability to declare no need with ADLs (0.42 with IADLs, p<0.0001), increases by 0.10 (p<0.0001) the number of reported needs with ADLs (0.92 with IADLs, p<0.0001) and reduces by 0.0002 (p=0.606) the probability to report unmet/undermet needs with ADLs (0.10 with IADLs, p=0.0098).

based on subjects' health and disabilities. The results unambiguously support the idea that the subjectivity of the proxy respondents', most often recruited among the caregivers of the surveyed elderly, inflates the probability to declare needs and the number of reported needs for care with ADLs and IADLs and deflates the probability to declare unmet/undermet needs. As a result, the impact of the use of proxy respondents in population health survey must undoubtedly require attention and suitable treatments in the forthcoming research on that topic, without which the predictions of needs for long-term care would be undermined and public policies aimed at planning care provision not relevant (de Meijer et al., 2015; Van Houtven and Norton, 2004). Moreover, the functional limitations are involved in a dynamic process and so are disabilities and needs for care with ADLs and IADLs (Hill and Pylypchuk, 2006). A challenging issue is then to assess how the respondent bias, depending on where the proxy, as a respondent, is located in her learning curve about the subject and, as a caregiver, in her knowledge of the elderly she is used to providing care, may evolve in a dynamic perspective.

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