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The use of multilevel models to explain regional disparities:
## illustration on pneumococcal vaccination

Introduction

The regional disparities on an epidemiologic criterion can be explained by both the characteristics of the region (socio economic level, care network) and the case-mix of the inhabitants of the region. This information is hierarchical and the individuals of the same region are correlated. The multilevel models are a type of mixed model designed to deal with this specific problematic.

Objective

The aim of this study is to present an illustration of multilevel models with two levels information (patients and region) in the context of regional disparities using 2018 data of diabetic adults from the Covarisq study[1].

Methods

Generalized hierarchical mixed linear model[2]
Binomial distribution and a logit link
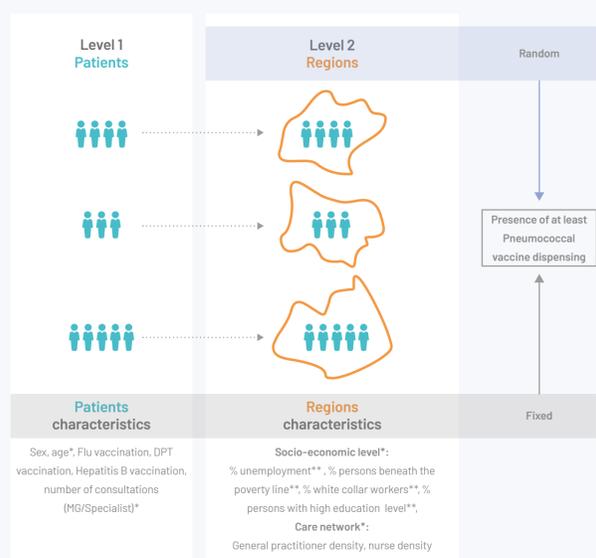
*For continuous covariates, piecewise linear regression was implemented.

**As variable for socio-economic level are highly correlated, only one variable among them is included in multivariable models

Conclusion

In this illustration, significant associations were found on predictor of vaccinations including patients' characteristics and regional characteristics. Differences at a regional level are interesting to implement public health campaign. The variability between departments were not fully explained by observed characteristics of patients and characteristics of regions.

The multilevel models are well suited to study the regional disparities as regions and patients correspond to hierarchical data. These models allow to consider several level of covariates.

References
1. Wyplosz B, Fernandes J, Sultan A, Roche N, Roubille F, Loubet P, et al. Pneumococcal and influenza vaccination coverage among at-risk adults: A 5-year French national observational study. Vaccine [Internet]. 2022 Jul 7 [cited 2022 Jul 18]; Available from: https://www.sciencedirect.com/science/article/pii/S0264410X22008416
2. Peugh, J. L. (2010). A practical guide to multilevel modeling. Journal of school psychology, 48(1), 85–112.

Results

Prevalent diabetic patients in 2018
2,374,070

Pneumococcal vaccine coverage rate

1.8% Total France   **0.4%** Lowest Martinique   **2.4%** Highest Bretagne

Association between patients and regions characteristics and pneumococcal vaccination
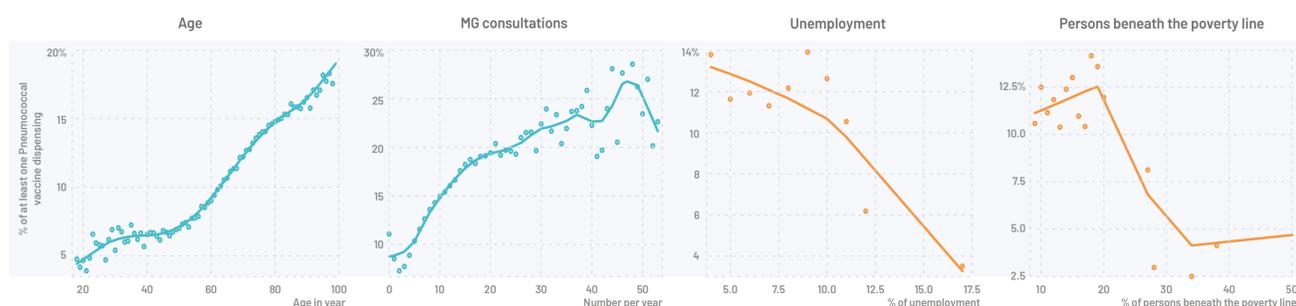
Multilevels model – Fixed effect results

Effect	Estimate	Standard error	OR	95% CI	P-value
Intercept	-3.429	0.152			<.0001
Patients characteristics					
Sexe					
Women	0	.	1.000		.
Men	0.074	0.004	1.077	1.068-1.086	<.0001
Age					
Age<60 years	0.098	0.040	1.102	1.017-1.195	0.016
Linear effect before 60 years	0.011	0.001	1.011	1.010-1.013	<.0001
Linear effect after 60 years	0.015	.	1.015	1.014-1.016	<.0001
Up to date for Flu vaccine					
No	0	.	1.000		.
Yes	0.844	0.005	2.325	2.303-2.348	<.0001
Up to date for DPT vaccine					
No	0	.	1.000		.
Yes	0.511	0.004	1.667	1.653-1.682	<.0001
Up to date for Hepatitis B vaccine					
No	0	.	1.000		.
Yes	0.876	0.012	2.401	2.346-2.457	<.0001
Number of General practitioner appointements					
Less than 20	-0.838	0.034	0.432	0.404-0.463	<.0001
Linear effect for less than 20	0.050	<0.001	1.052	1.051-1.053	<.0001
Linear effect for more than 20	0.005	0.001	1.005	1.003-1.007	<.0001
Number of specialist appointements					
Less than 10	-0.305	0.019	0.737	0.709-0.766	<.0001
Linear effect for less than 10	0.046	0.001	1.047	1.045-1.049	<.0001
Linear effect for more than 10	0.007	<0.001	1.007	1.006-1.008	<.0001
Regional characteristics					
General practitionner density					
Linear effect	0.001	0.002	1.001	0.997-1.005	0.552
Nurse density					
Linear effect	<0.001	<0.001	1.000	0.999-1.001	0.678
Percentage of unemployment under 10%					
No	0	.	1.000		.
Yes	0.271	0.078	1.312	1.123-1.532	<.001

Interpretation for patients characteristics:

Diabetics patients with others vaccinations have a chance of vaccination multiplied from 1.67 (DPT vaccine) to 2.40 (Hepatitis B vaccine).

Patients with more than 20 general practitioner appointments per year have a higher chance of vaccination multiplied by 2.31 (An increase of the number of appointments beyond 20 appointments per year has a small magnitude).

Patients with less than 20 general practitioner appointments per year have a chance of vaccination increased by 5.2% per appointment.
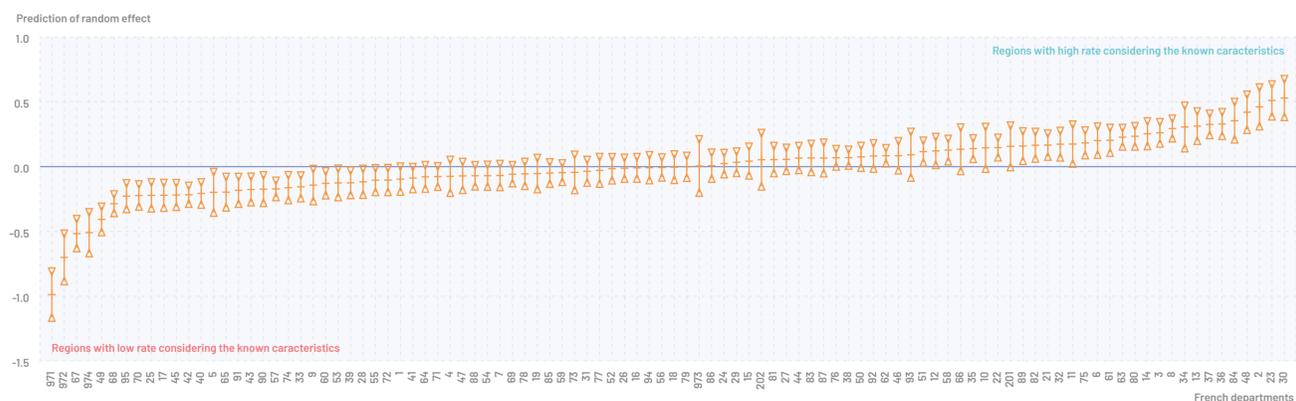
Interpretation for region characteristics:

For patients living in an area with less than 10% of unemployment, the chance of vaccination are multiplied by 1.31 compared the patients in an area with more than 10% of unemployment.

For patients living in an area with less than 20% of its inhabitants living beneath the poverty line, the chance of vaccination are multiplied by 1.31 compared to patients living in an area with more than 20% of its inhabitants living beneath the poverty line (model not shown)

Multilevels model – Random effect results

After adjustment on covariates, the random effect on region was significant (variance at 0.06) with a significant predicted effect of over- and under-vaccination unexplained by covariates in several regions.