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Health-related biological and non-biological consequences of forgoing healthcare for economic reasons

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ABSTRACT

Forgoing healthcare for economic reasons has been previously associated with adverse health outcomes, including a higher risk of hospitalization, a lower quality of life, and worse self-reported health. However, the exact cause-to-effect relation between forgoing healthcare and health-related outcomes has been insufficiently described. Here, we investigate the prospective health consequences of forgoing healthcare for economic reasons using data from "ReBus" (N = 400), a prospective study examining the health consequences of forgoing healthcare (Baseline: 2008–2013, Follow-up: 2014–2016). Using regression models, we explored the baseline determinants of forgoing healthcare, including socioeconomic, demographic, and pre-existing health-risk factors, and examined the associations between forgoing healthcare at baseline and health deterioration at follow-up, using highly pertinent biomarkers (glucose, glycated hemoglobin, lipids, blood pressure) and SF-36 questionnaire data.

Low income, low occupation, low education, and smoking were associated with higher odds of forgoing healthcare at baseline. Forgoing healthcare for economic reasons at baseline was subsequently related to detrimental changes in glucose, high-density lipoprotein cholesterol (HDL), and blood pressure (BP) at follow-up, independently of baseline socioeconomic factors (Glucose-β = 0.19, 95%CI[0.03;0.34], HDL-β = -0.07, 95%CI [-0.14;0.01], BP-β = 3.30, 95%CI[-0.01;6.60]). Moreover, we found strong associations between forgoing healthcare and adverse SF-36 health scores at follow-up, with individuals forgoing healthcare systematically displaying worse health scores (6%–11% lower scores).

For the first time, we show that forgoing healthcare for economic reasons predicts adverse health-related consequences 2–8 years later. Our findings shall further encourage the implementation of public health measures aimed at identifying individuals who forgo healthcare and preventing the adverse health consequences of unmet medical needs.

1. Introduction

Forgoing or delaying healthcare is a major public health concern in many countries, including those with a universal healthcare coverage (Guessous et al., 2012; Reinhardt, 2004; Bazin et al., 2006; Bodenmann et al., 2014). Previous research has reported that forgoing healthcare

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occurs for a variety of reasons, including work constraints, family obligations, cultural factors, or personal beliefs (Guessous et al., 2012; Bazin et al., 2006; Rustgi et al., 2009). However, economic reasons were identified as the main determinants of forgoing healthcare, principally due to mandatory co-payments, high out-of-pocket expenses, and other health-related costs, which eventually lead to an inadequate use of healthcare services (Guessous et al., 2012; Rustgi et al., 2009; Petrelli et al., 2019).

Previous studies have also reported that forgoing healthcare for economic reasons is related to adverse health outcomes, including a higher severity of disease, a higher risk of hospitalization, poor self-reported health, and a lower quality of life (Guessous et al., 2012; Mielck et al., 2009; Weissman et al., 1991; Chen et al., 2011). However, the exact time-to-effect relation between forgoing healthcare and subsequent physical and mental health consequence is difficult to determine given the cross-sectional nature of former investigations.

Using data from Switzerland, a wealthy European country with a universal healthcare coverage, Guessous et al. previously observed a 14% prevalence of forgoing healthcare for economic reasons in the "Bus Santé" population-based survey (2007–2010) (Guessous et al., 2012). The study found that a lower income, a lower occupational position, receiving premium subsidies, and high insurance flat deductibles were significantly associated with a higher risk of forgoing healthcare for economic reasons (Guessous et al., 2012; Guessous, 2011; Bodenmann et al., 2014). This research also showed that forgoing healthcare was associated with adverse cardiometabolic risk factors (diabetes, hypertension, hypercholesterolemia), although these associations were investigated cross-sectionally (Guessous et al., 2012).

While these investigations provided extensive information on the factors related to forgoing healthcare, a series of important questions remain unanswered. In particular, whether forgoing healthcare actually leads to subsequent physical and mental health deterioration remains to be confirmed.

Here, we use data from a sub-study of the "Bus Santé" survey, the "ReBus" study, to investigate the prospective health-related consequences several years after reporting forgoing healthcare for economic reasons, while taking into consideration socioeconomic circumstances at baseline. In particular, we examine to what extent forgoing healthcare affects subsequent changes in highly pertinent biomarkers and clinical measures, including blood glucose, plasma lipids, and blood pressure, whose dysregulation leads to major metabolic and cardiovascular disorders, and which account for the leading cause of death in Western countries (Rapsomaniki et al., 2014; Castelli et al., 1986; Grundy, 1986; Collaboration, 2010). Furthermore, we explore the associations between forgoing healthcare at baseline and nine physical and mental health scores at follow-up, collected through the standard SF-36 health questionnaire, and which have been consistently related to multiple health outcomes, including cardiovascular disorders, mental illnesses, overall well-being, and premature mortality (Ware, 1999; Jenkinson et al., 1994; Zhang et al., 2010).

2. Methods

2.1. Participant enrollment and study sample

The study sample came from the "Bus Santé" population-based survey (Guessous et al., 2012; Guessous, 2011). Briefly, "Bus Santé" is an ongoing, repeated, cross-sectional study conducted in the canton of Geneva (Switzerland) since 1993, with the purpose of monitoring health-related risk factors at the community level (Morabia et al., 1997; Guessous et al., 2014). Eligible subjects are identified every year from the canton's annual resident list, and selected to match the canton's non-institutionalized residents aged 20–74 years (Guessous, 2011; Morabia et al., 1997). Participant selection is performed using stratified random sampling across age and sex-specific strata, proportionally to the frequencies observed in the general population (Guessous, 2011; Morabia et al., 1997). Potential subjects are invited by postal mail to participate to the study, and, in case of non-response, up to seven telephone attempts are made at different times on various days of the week (Guessous, 2011; Morabia et al., 1997). If telephone contact is unsuccessful, two additional letters are mailed. Subjects who could not be reached are replaced using the same selection process, whereas those refusing to participate are not replaced.

Each included participant takes part to a medical visit during which anthropometric characteristics, blood pressure, and blood biomarkers (glucose, plasma lipids) are obtained. During the visit, participants are asked to complete a self-administered questionnaire inquiring about socioeconomic characteristics, health behaviors, self-reported health, and medical history. Study participants are given a medical certificate for their employer in case of a missed workday, and their biomarker and blood pressure results are sent to them after the interview, including a recommendation to visit their general practitioner in case of abnormal values. No financial compensation is provided to study participants. As of 2020, 28,473 individuals had participated to the "Bus Santé" study, with an annual participation rate ranging between 50% and 70% from 1993 to 2020 (Guessous et al., 2014; Galobardes et al., 2003; Stringhini et al., 2020).

The "ReBus" subjects were selected from a pool of "Bus Santé" participants (**baseline examination**: 2008–2013) who either reported forgoing healthcare, or not. To allow a meaningful comparison between those who reported forgoing healthcare versus those who did not forgo healthcare, "ReBus" participants were identified using stratified random sampling, with strata being defined based on age, sex, insurance flat deductibles, and civil status. Of the 600 individuals initially invited to participate (300individualsforgoinghealthcare,300notforgoinghealthcare), 400 subjects were included in the "ReBus" study, using the same enrollment/contact process as for "Bus Santé" (participation rate 67%). Upon selection, "ReBus" subjects were invited for a follow-up visit 2–8 years after the baseline examination (**follow-up examination**: 2014–2016), including a standard anthropometric and medical examinations, blood sampling for biomarkers (glucose, plasma lipids, glycated hemoglobin), and an assessment of self-reported health using the 36-Item Short Form Survey (SF-36) (Ware, 1999; Ware, 2000). As for "Bus Santé", "ReBus" participants were given a medical certificate for their employer in case of a missed workday, and received their biomarker and blood pressure results via postal mail, including a recommendation to see their general practitioner in case of abnormal values. No financial compensation was provided, except for covering travel expenses to the study center, to a maximum of 25 Swiss Francs (1CHF ≅ 1USD).

Both "Bus Santé" and "ReBus" studies were approved by the Ethics committee of the Geneva University Hospitals (Protocol number: 10-030R), and all included participants signed written informed consent.

3. Variables

3.1. Forgoing healthcare for economic reasons

Participants self-reported forgoing healthcare for economic reasons at the baseline examination by answering to the question: "*During the previous 12 months, have you forgone certain types of healthcare services due to price?*". If the answer to the question was "Yes", participants were further asked to report which type of healthcare was forgone, including surgery, general practitioner consultation, specialist consultation, medication, dental care, re-adaptation in hospital, ambulatory re-adaptation, devices (i.e. hearing devices, glasses), care in medical center, home care, home assistance, and any other type of healthcare services.

3.2. Demographic, socioeconomic, and health-related risk factors

We used country of origin as a baseline demographic indicator that

was categorized as Swiss vs. non-Swiss. We used occupational position, education, and household income as indicators of socioeconomic position at baseline. Occupational position was based on self-reported job title and subdivided into three categories: "high" (large employers, high-level professionals and managers), "middle" (mid-level professionals and managers, small employers/self-employed), and "low" (clerks, manual workers, unqualified employees), using the European Socio-economic Classification system (Harrison and Rose, 2006). Highest level of attained education was self-reported according to the International Standard Classification of Education and subsequently subdivided into three groups: "high" (university education), "middle" (higher secondary education), and "low" (lower secondary education or lower) (OECD, 1999). Monthly household income was also self-reported and further adjusted for household composition according to the OECD-modified scale formula (Chanfreau and Burchardt, 2008). Further, the level of annual flat deductibles, which is the annual mandatory contribution to health expenses, was included as an additional, baseline socioeconomic determinant and classified into three groups: "300–500 CHF", "1000–1500 CHF", "2000–2500 CHF".

In addition to demographic and socioeconomic indicators, we used smoking, self-reported cardiometabolic disorders (binary: hypertension, diabetes, high cholesterol), self-reported medication intake (binary: anti-hypertension, anti-diabetes, anti-cholesterol drugs), and self-reported health (5 categories: Excellent-Poor) as health-related risk factors at baseline.

3.3. Biomarkers and arterial blood pressure

We examined the difference in five blood biomarkers and arterial blood pressure between the follow-up and baseline examinations. These markers were chosen based on their established link with major cardiometabolic disorders, including diabetes, hypertension, coronary heart disease, stroke, and other cardiovascular diseases (Rapsomaniki et al., 2014; Castelli et al., 1986; Grundy, 1986; Collaboration, 2010). Blood biomarkers included glucose, glycated hemoglobin, total cholesterol, triglycerides, and high-density lipoprotein cholesterol (HDL), which were measured from fasting blood samples at the Geneva University Hospitals laboratory by using the same standard procedures at both examinations (Guessous et al., 2014). Blood pressure measurements were performed by qualified nurses using the same standard procedures at both examinations (Guessous et al., 2014).

3.4. SF-36 health scores

We assessed physical and mental self-reported health scores at follow-up examination using the Short Form-36 self-administered questionnaire (SF-36, validated French version) (Ware, 1999; Ware, 2000). Briefly, the SF-36 questionnaire allows computing eight health scores, which have been consistently related with multiple health outcomes, and which comprise: **1-the physical functioning score**, **2-the role-physical score, 3-the bodily pain score**, **4-the general health score**, **5-the vitality score**, **6-the social functioning score**, **7-the role-emotional score**, and **8-the mental health score,** whose descriptions are provided in Appendix I (Ware, 2000; Ware et al., 2000). We further included a ninth **health transition score**, assessing current health in comparison to the previous year, and calculated all nine scores according to the "Transformed Scale Formula", ranging from 0: least favorable score, to 100: most favorable score (Ware et al., 2000). We evaluated the internal consistency of the nine SF-36 scores using the Cronbach's α statistic (Supplementary Table 1), with all nine scores displaying a very good internal consistency ($\alpha > 0.86$) (Jenkinson et al., 1994).

3.5. Statistical analyses

We first tested the associations between baseline demographic, socioeconomic, and health-related risk factors (predictor variables) and forgoing healthcare for economic reasons (outcome variable) using logistic regression models adjusted for sex and age at baseline. This initial step allowed to identify baseline socioeconomic and health-related factors which may potentially confound, or distort the relation between forgoing healthcare at baseline and subsequent health outcomes (FRANK, 2000). We then investigated the relation between forgoing healthcare for economic reasons at baseline and health-related consequences at follow-up by using linear regression, with the main covariates/confounders including sex, age at baseline, age at follow-up, and baseline socioeconomic and health-related risk factors identified previously. First, we examined the association between forgoing healthcare at baseline and biomarkers/blood pressure difference by applying linear regression. We implemented two regression models: a first model adjusted for the main covariates (M1), and a second model (M2) additionally adjusted for baseline cardiometabolic disorders (CMD: high blood pressure, diabetes, high cholesterol), and baseline medication intake (anti-hypertension, anti-diabetes, anti-cholesterol drugs). Second, we tested the associations between forgoing healthcare and nine SF-36 health scores also using two regression models: a first model adjusted for the main covariates (M1), and a second model additionally adjusted for baseline self-reported health (M2), which was imputed using multiple imputation procedure (45% missing values – N = 20 imputations based on sex, age, self-reported hypercholesterolemia, diabetes, high blood pressure, cardiovascular disorders, and medication intake at baseline).

Statistical significances for associations were set at $P < .05$. We conducted all statistical analyses using STATA v.15 (Stata Corp, College Station, TX, USA) and R statistical software v.4.0.2 (Vienna, Austria).

4. Results

Table 1 summarizes the characteristics of "ReBus" participants by forgoing healthcare status at baseline. The sample included 179 men and 221 women. The mean age at baseline ranged between 45 and 50 years, with younger individuals forgoing healthcare more frequently. Furthermore, individuals with a lower socioeconomic position, smokers, and those reporting poor self-rated health at baseline were more frequently in the forgoing healthcare group. Among the participants forgoing healthcare, the most common types of forgone services were dental care (59%), specialist consultation (49%), devices (47%), generalist practitioner consultation (29%), medication (23%), surgery (13%), and the remaining types of healthcare (≤11%).

We show the associations between demographic, socioeconomic, and health-related risk factors with forgoing healthcare for economic reasons at baseline in Table 2. We confirmed that a lower education, a lower occupational position, and a lower household income were significantly associated with an increased risk of forgoing healthcare for economic reasons (Education: OR = 2.04, 95%CI[1.25;3.33], $P = .005$, Occupational position: OR = 2.16, 95%CI[1.16;4.02], $P = .015$, Household income: OR = 5.32, 95%CI[3.01;9.39], $P < .001$), while country of origin and health insurance deductibles were not significantly associated. Among health-related risk factors, we found that smoking and poor self-reported health were significantly associated with forgoing healthcare for economic reasons at baseline (Smoking: OR = 1.71, 95%CI [1.06;2.76], $P = .029$, Self-reported health (lowest vs. highest): OR = 3.18, 95%CI[1.16;5.20], $P = .005$), whereas no associations were observed for baseline cardiometabolic disorders and related medication intake.

In Fig. 1, we present the linear associations between forgoing healthcare for economic reasons at baseline and biomarkers/blood pressure difference between the follow-up and baseline examinations. We found that forgoing healthcare at baseline was associated with a significant increase in blood glucose at follow-up ($\beta_{M1} = 0.17$, 95%CI [0.01;0.32], $P = .033$), as well as a decrease in HDL cholesterol and an increase in maximum average blood pressure, but these associations

Table 1
Baseline characteristics of included "ReBus" participants (Baseline: 2008–2013, N = 400).

	Not forgoing healthcare (N = 228)	Forgoing healthcare (N = 172)	*P* [a,b]
Women (N,%)	125 (55%)	96 (56%)	0.844
Swiss origin (N,%)	164 (74%)	114 (69%)	0.301
Age at baseline (μ ± SD)	49.6 (±10)	45.8 (±11.5)	0.002
Age at follow-up (μ ± SD)	55.2 (±10)	50.8 (±11.8)	<0.001
Education (N,%)			
High	101 (45%)	57 (34%)	0.044
Middle	61 (27%)	47 (28%)	
Low	62 (28%)	64 (38%)	
Occupational position (N,%)			
High	56 (29%)	19 (15%)	0.013
Middle	71 (37%)	54 (43%)	
Low	65 (34%)	54 (43%)	
Household income (N, %)			
>13000 CHF	56 (25%)	10 (6%)	<0.001
9500–13000 CHF	49 (22%)	22 (14%)	
7000–9500 CHF	55 (25%)	37 (23%)	
5000–7000 CHF	26 (12%)	33 (21%)	
3000–5000 CHF	26 (12%)	42 (26%)	
<3000 CHF	8 (4%)	15 (9%)	
Annual flat deductibles (N,%)			
300–500 CHF	120 (54%)	88 (53%)	0.079
1000–1500 CHF	66 (29%)	37 (22%)	
2000–2500 CHF	38 (17%)	42 (25%)	
Current smoking (N, %)	42 (19%)	49 (28%)	0.019
Cardiometabolic disorders (N,%)			
Hypertension	56 (25%)	42 (24%)	0.974
Diabetes	8 (4%)	8 (5%)	0.564
High cholesterol	49 (21%)	42 (24%)	0.489
Medication intake (N, %)			
Anti-hypertension medication	29 (13%)	13 (8%)	0.096
Anti-diabetes medication	3 (1%)	3 (2%)	0.727
Anti-cholesterol medication	15 (7%)	12 (7%)	0.875
Self-reported health (N,%)			
Excellent	33 (29%)	16 (14%)	0.008
Very good	63 (56%)	62 (55%)	
Good	13 (12%)	28 (25%)	
Fair	3 (3%)	5 (4%)	
Poor	0 (0%)	2 (2%)	
Type of forgone healthcare (N,%)			
Surgery		21 (13%)	
General practitioner consultation		48 (29%)	
Specialist consultation		81 (49%)	
Medication		39 (23%)	
Dental care		99 (59%)	
Re-adaptation in hospital		1 (0.6%)	
Ambulatory re-adaptation		3 (2%)	
Devices		79 (47%)	
Care in medical center		5 (3%)	
Home care		4 (2%)	
Home assistance		7 (4%)	
Any other type of healthcare		19 (11%)	

Data are mean ± SD for continuous variables and n (%) for categorical variables.
[a] The Mann-Whitney *U* test was performed for continuous variables (age at baseline, age at follow-up).
[b] The $\chi 2$ test was performed for categorical variables.

Table 2
Association between demographic, socioeconomic, and health-related risk factors and forgoing healthcare at baseline (Baseline: 2008–2013, N = 400).

Demographic/socioeconomic factors	OR [95%CI] [a]	*P* [a]	N
Swiss origin	0.82 [0.52; 1.30]	0.403	387
Education (LH)	2.04 [1.25; 3.33]	0.005	392
Occupational position (LH)	2.16 [1.16; 4.02]	0.015	319
Household income adj. (Tertiles-LH) [b]	5.32 [3.01; 9.39]	<0.001	379
Deductibles (LH)	1.07 [0.63; 1.83]	0.806	391
Health-related risk factors			
Smoking	1.71 [1.06; 2.76]	0.029	399
Hypertension	1.28 [0.78; 2.09]	0.325	400
Diabetes	1.61 [0.58; 4.46]	0.358	400
High cholesterol	1.64 [0.98; 2.74]	0.058	400
Anti-hypertension medication	0.83 [0.40; 1.74]	0.628	400
Anti-diabetes medication	1.65 [0.32; 8.51]	0.551	400
Anti-cholesterol medication	1.61 [0.70; 3.73]	0.265	400
Self-reported health (LH) [c]	3.33 [1.09; 5.56]	0.005	398

OR, odds ratio; CI, confidence interval; LH, lowest vs. highest category cardiovascular disorders, and medication intake at baseline).
[a] Logistic regression for the association between demographic, socioeconomic, and health-related risk factors (predictors) and forgoing healthcare (outcome), adjusting for sex and age at baseline.
[b] Income adjusted for household composition (OECD-modified scale formula) - Tertiles: lowest vs. highest.
[c] Self-reported health was imputed (N = 20 imputations, 45% missing values) based on sex, age, self-reported hypercholesterolemia, diabetes, high blood pressure.

failed to reach statistical significance (HDL cholesterol: β_{M1} = -0.06, 95%CI[-0.13;0.00], *P* = .066; Maximum BP difference: β_{M1} = 3.30, 95% CI[-0.01;6.61], *P* = .051). Further adjusting for baseline cardiometabolic disorders and baseline medication intake only marginally affected the tested associations, yielding similar regression coefficients for all biomarkers across both models.

In Fig. 2, we show the associations between forgoing healthcare at baseline, and the nine SF-36 scores at follow-up. We found that forgoing healthcare at baseline was significantly associated with eight out of nine SF-36 scores in the first model (M1), whereby individuals forgoing healthcare systematically reported worse scores (4% to 13% average lower health scores), except for the 9-health transition score (β_{M1} = -2.58, 95%CI[-7.22;2.06], *P*=.275). Accounting for baseline self-reported health lead to an attenuation of the association between forgoing healthcare at baseline and SF-36 scores at follow-up, whereby five out nine scores remained statistically significant, including the 1-role-physical score, the 3-bodily pain score, the 6-social functioning score, the 7-role-emotional score, and the 8-mental health score (6% to 11% average lower health scores).

5. Discussion

In this study, we explored the baseline determinants and the prospective health-related consequences of forgoing healthcare for economic reasons. We found that having a lower education, a lower occupation, and a lower income was significantly associated with a higher risk of forgoing healthcare at baseline. Furthermore, forgoing

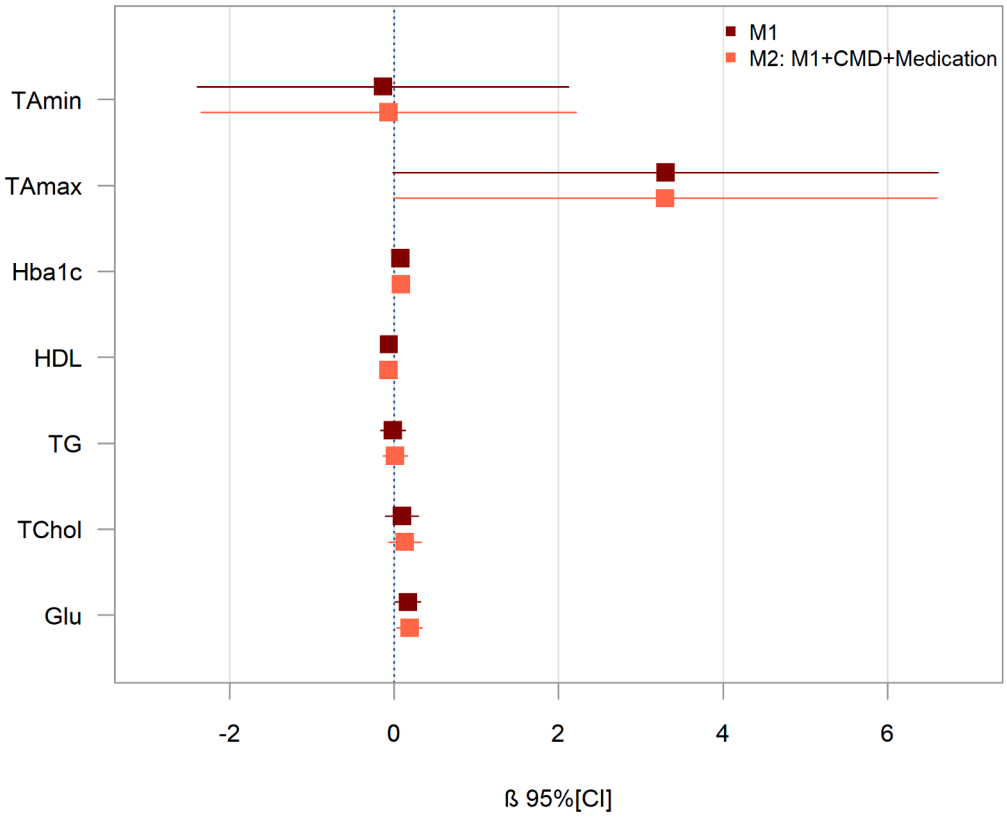

Fig. 1. Association between forgoing healthcare at baseline and difference in blood biomarkers and arterial blood pressure between follow-up and baseline (Baseline: 2008–2013 - Follow-up: 2014–2016, N = 400) β, linear regression coefficient; CI, confidence interval; Glu, glucose; TChol, total cholesterol, TG, triglycerides, HDL, HDL cholesterol; Hba1c, glycated hemoglobin; TAmax, maximum average blood pressure difference, TAmin, minimum average BP difference, CMD, cardiometabolic disorders M1: Linear regression for the association between forgoing healthcare and biomarkers change (follow-up - baseline), adjusting for sex, age at baseline, age at follow-up, education, occupational position, and income (Table 2) M2: Linear regression for the association between forgoing healthcare and biomarkers change (follow-up - baseline), *additionally* adjusted for baseline hypercholesterolemia, high blood pressure, diabetes status and related medication intake at baseline (anti-hypertension drugs, anti-diabetes drugs, anti-cholesterol).

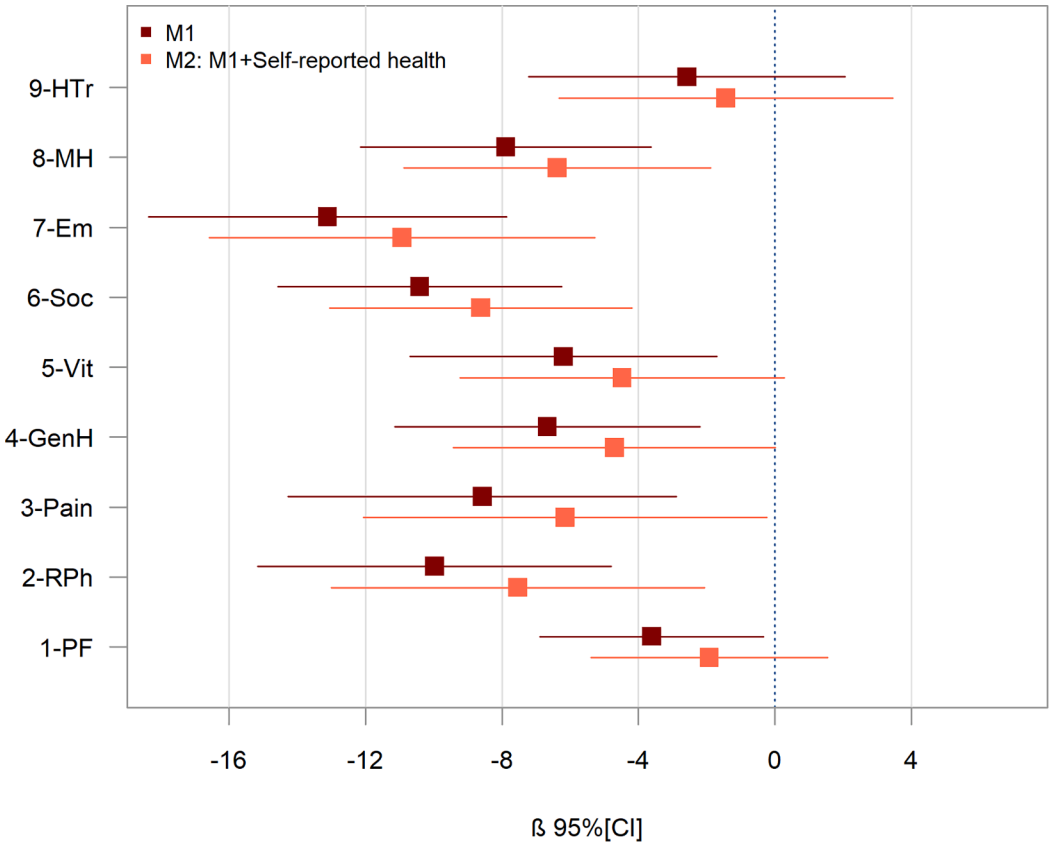

Fig. 2. Association between forgoing healthcare at baseline and SF-36 health scores at follow-up (Baseline: 2008–2013 - Follow-up: 2014–2016, N = 400) β, linear regression coefficient; CI, confidence interval; PF, physical functioning; RPh, role-physical; Pain, bodily pain; GenH, general health; Vit, vitality; Soc, social functioning; Em, role-emotional; MH, mental health; HTr, health transition M1: Linear regression for the association between forgoing healthcare at baseline and SF-36 health scores, adjusting for sex, age at baseline, age at follow-up, education, occupational position, income, and smoking M2: Linear regression for the association between forgoing healthcare at baseline and SF-36 health scores, *additionally* adjusted for baseline self-reported health (N = 20 imputations, 45% missing values – imputation based on sex, age, self-reported hypercholesterolemia, diabetes, high blood pressure, and cardiovascular disorders at baseline.

healthcare was associated with detrimental changes in blood glucose as well as HDL cholesterol and blood pressure, while there were no differences for the remaining biomarkers. Finally, we found strong associations between forgoing healthcare for economic reasons at baseline and adverse physical, emotional, and social SF-36 health scores at follow-up.

The associations between a lower socioeconomic position and a higher risk of forgoing healthcare at baseline are in line with previous findings from "Bus Santé" and other population-based studies (Guessous et al., 2012; Mielck et al., 2009; Bodenmann et al., 2014; Feral-Pierssens et al., 2020; Guinchard et al., 2015). These relations may be explained by the fact that the majority of countries with universal healthcare have set-up mechanisms to contain health expenditures, including mandatory co-payments, deductibles, exclusion of certain care types (i.e. dental care), high out-of-pocket expenses, and other cost participation plans, which eventually constitute major financial barriers in healthcare access and use by socioeconomically deprived groups, characterized by a low education, a low occupation, and a low income (Bazin et al., 2006; Petrelli et al., 2019; Guessous, 2011; Feral-Pierssens et al., 2020; van Doorslaer et al., 2000; Guessous et al., 2014). In particular, we observed that dental care was the most common type of care forgone, which is explained by the fact that dental care is not included in the mandatory health insurance plan in Switzerland, and may constitute a major financial burden for economically disadvantaged individuals (Guessous et al., 2014; Sandoval et al., 2021; Saekel, 2016). Furthermore, previous research has also highlighted the role of psychosocial factors, such as personal beliefs, fear of stigma, or mistrust in the medical system, which are often driven by socioeconomic and cultural determinants (i.e. education, health literacy, migrant origin, religious background), and may lead to forgoing or misusing healthcare services (Bazin et al., 2006; Tseng et al., 2013; Gusmano et al., 2014).

In addition to socioeconomic factors, we found that smoking and self-reported health at baseline were associated with higher odds of forgoing healthcare for economic reasons. The relation between smoking and forgoing healthcare has been previously observed, and may be explained, or confounded, by a low socioeconomic position (Guessous et al., 2012; Petrovic et al., 2018). Indeed, previous research has reported that socioeconomically disadvantaged individuals tend to be less conscious about health or health monitoring, which may translate into unhealthy behaviors and an inadequate use of healthcare services (Guessous, 2011; Petrovic et al., 2018; Marmot and Wilkinson, 2005; Wardle and Steptoe, 2003). The association between poor self-reported health and forgoing healthcare was also observed previously (Guessous et al., 2012), however, the cross-sectional nature of this association renders interpretation difficult, as it is unknown whether forgoing healthcare precedes self-reported health in this particular setting.

We found that forgoing healthcare at baseline was meaningfully associated with detrimental changes in glucose at follow-up, and tended to be related with adverse changes in HDL-cholesterol and blood pressure. While previous studies have reported an association between forgoing healthcare and poor, subsequent, self-reported health (Weissman et al., 1991; Chen et al., 2011), our study is the first to investigate the prospective effects of forgoing healthcare on blood biomarkers and blood pressure. Hence, our results provide novel evidence for a detrimental, yet modest, physiological effect of forgoing healthcare, likely resulting from an inadequate health monitoring or poor health prevention (Feral-Pierssens et al., 2020; Piette et al., 2004). Interestingly, we observed a relatively low effect-size and no significant differences for triglycerides, total cholesterol and glycated hemoglobin between the two study phases. These results may be explained by the participants' age at baseline (mean age: 48 years) and the short time period between the baseline and follow-up examinations (mean time difference: 4.8 years), which may be insufficient for detecting major biomarkers changes in a middle-aged population (Uranga and Keller, 2010; Suvila et al., 2020). We further observed that additionally adjusting for baseline cardiometabolic disorders and medication intake only marginally changed the associations between forgoing healthcare and biomarkers difference between the two study phases. These findings may be related to the fact that cardiometabolic disorders *and* medication intake were not associated with forgoing healthcare at baseline, likely due to a low statistical power as well as to the participants relatively young age at baseline.

Finally, we found strong associations between forgoing healthcare at baseline and adverse physical, mental health, vitality, and social SF-36 health scores at follow-up. These results tend to be in line with former studies, which reported that forgoing or delaying healthcare is associated with subsequent poor self-reported health, a lower quality-of-life, a higher risk of hospitalization, and longer hospital stays (Weissman et al., 1991; Chen et al., 2011; Heisler et al., 2004). When compared to previous research, our study is the first to report a detrimental effect of forgoing healthcare on multiple SF-36 health scores, which are a valid tool for assessing self-reported health and which have been previously found to predict cardiovascular outcomes, hospitalizations, and mortality (Jenkinson et al., 1994; Ware, 2000; Perneger et al., 1995; Lins and Carvalho, 2016; Saquib et al., 2013; Fan et al., 2004). While these results tend to indicate that forgoing healthcare for economic reasons has a pleiotropic effect on subsequent self-reported health, the observed associations may also be influenced by baseline SF-36 health scores, which were not available in the present study, or other, unknown confounding factors (FRANK, 2000).

6. Strengths and limitations

Our study has several strengths, the first being the prospective examination of health-related consequences resulting from forgoing healthcare for economic reasons at baseline. Second, this is the first study to assess objective *and* subjective health changes using measured biomarkers and validated health scores.

Our study also has limitations to acknowledge. First, the small sample size may have led to statistical power issues resulting in undetected associations. This represents a particular issue when considering the specific effects of different types of forgone healthcare services. For instance, only five out of twelve healthcare services were forgone by>15% of the participants, and the majority reported forgoing multiple types of healthcare services simultaneously. Second, the short time period between the two examinations and the relatively young age of "ReBus" participants represents another important limitation, as it precludes detecting major chronic diseases such as diabetes, hypertension, or cardiovascular outcomes, which generally present a long pathophysiological process and tend to occur after the age of 50 (Rapsomaniki et al., 2014; Uranga and Keller, 2010; Suvila et al., 2020; Yazdanyar and Newman, 2009). Third, the effect of unmeasured confounding variables, which may distort the relation between forgoing healthcare at baseline and health scores at follow-up, represents another important limitation of this work (FRANK, 2000). Indeed, the SF-36 questionnaire data was available at follow-up only, which precluded accounting for physical and mental health scores at baseline. However, we partially addressed this issue by accounting for a 5-level indicator of self-reported health at baseline. Finally, another important unmeasured confounding may be related to the overall time period during which healthcare was forgone and which was not assessed in this research.

7. Conclusion

In summary, our findings show a meaningful prospective effect of forgoing healthcare for economic reasons on adverse subjective *and* objective health outcomes. Future research should investigate the specific health effects of the type of forgone healthcare, as certain types of care are more frequently forgone than others (i.e. dental care, specialist care). Furthermore, considering the negative impact of forgoing healthcare, our findings should encourage the implementation of public health policies aimed at identifying individuals who forgo healthcare,

targeting frequently forgone healthcare services, and further preventing the detrimental health consequences resulting from unmet medical needs at both individual and population levels.

8. Compliance with ethical standards

The "Bus Santé" and the "ReBus" studies were approved by the Ethics committee of the Geneva University Hospitals (Protocol number: 10-030R).

CRediT authorship contribution statement

Dusan Petrovic: Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. **Kailing Marcus:** Data curation, Investigation, Resources, Writing – original draft, Writing – review & editing. **José Sandoval:** Data curation, Investigation, Resources, Visualization, Writing – original draft, Writing – review & editing. **Stéphane Cullati:** Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Giovanni Piumatti:** Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Patrick Bodenmann:** Investigation, Methodology, Writing – original draft, Writing – review & editing. **Yves-Laurent Jackson:** Investigation, Methodology, Writing – original draft, Writing – review & editing. **Claire Durosier Izart:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing. **Hans Wolff:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Idris Guessous:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. **Silvia Stringhini:** Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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