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The rational use of glucocorticoids may reduce the risk of readmission in menopausal women with knee osteoarthritis: results from a five-year longitudinal study

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Abstract

Objective To investigate the effect of glucocorticoids (GCs) on the risk of readmission in menopausal women with knee osteoarthritis (OA).

Information and methods The study cohort comprised 80 menopausal women with knee OA treated at a tertiary hospital affiliated with Shanxi Medical University and who underwent follow-up between September 2018 and September 2023. Then the collected longitudinal monitoring data were used to construct a semi-variable coefficient shared Gamma frailty model (VCSGF). Based on the results of this model, we explored the impact of GCs on menopausal women with knee OA and made risk predictions.

Results The mean patient age at study entry was 64.7 ± 9.3 (range 50–82 years). And during the research, patients were admitted to the hospital a mean of 2.4 ± 1.8 times (range 1–11 times). Compared to patients who have not used the drug, the risk of early readmission in patients who have used GCs was reduced by 96% (HR = 0.04, 95%*CI*: 0.006 ~ 0.284, $P < 0.001$). This protective effect diminished over time ($\gamma_{2l}(t_0) = 0.629, P < 0.001$). In addition, the risk of hospital admission with recurrent symptoms was roughly 3.35-fold higher in patients who drink alcohol than in patients who do not (95%*CI*: 1.661~6.794, $P < 0.001$).

Conclusion GC use reduced the risk of readmission in menopausal women with knee OA, although this effect diminished over time. Therefore, in patients without further contraindications, GCs may be used in moderation to reduce the readmission risk. In clinical practice, additional research is needed to investigate the timing and appropriate use of GC in the treatment of menopausal women with knee OA, and to develop a more rational program for GC use.

Keywords Menopause, Osteoarthritis, Recurrent event data, Public health, Random effect model

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Osteoarthritis (OA), a highly prevalent global chronic disease, causes a serious disease and economic burden as the disease progresses [1–4]. Globally, approximately 527 million people living with arthritis now [5]. Knee osteoarthritis (KOA) is a common osteoarthritis and causes pain, swelling, limited joint function and impaired mobility [6]. Patients will be repeatedly admitted to hospitals due to these symptoms, resulting in a waste of medical resources. In public health, KOA requires increased attention because of its high rate of disability and impact on healthy life expectancy [7]. Currently, various interventions are available for patients with OA, including medicine [8], knee braces [9], exercise, and health education [10]. However, the efficacy of medicine for certain special populations, such as menopausal women (because of their special bone metabolism), requires further investigation.

Women are more likely to develop KOA than men [11], and the difference in prevalence is greater after menopause [12], possibly attributed to differences in serum oestrogen levels [13]. Physiologically, oestrogen protects osteoblasts from apoptosis and enhances their proliferation, maturation, and ossification. This protective effect on bone is lost in the absence of oestrogen, and osteoclastogenesis and bone resorption increase [14]. The structure of women's joints changes, leading to increased risks of developing a range of orthopaedic conditions including osteoporosis and KOA. Therefore, this patient population should be even more deserving of attention.

Knee OA involves the joint space and has several pathogenic mechanisms. Localized inflammation is a key mechanism of joint damage in knee OA and represents a potential therapeutic target [15]. Glucocorticoids (GCs) are multitargeted anti-inflammatory drugs widely used in clinical practice for the treatment of inflammatory, allergic and autoimmune diseases. The main mechanisms of GCs include the inhibition of pro-inflammatory cytokines and chemokines and the induction of the production of proteins with anti-inflammatory activity [16]. It is now well established that GCs can be used for anti-inflammatory and analgesic purposes in patients with knee OA [17].

Knee OA is a degenerative disease, and patients do not die directly from this condition. Most studies examining the efficacy of GCs in OA have used various pain scores [15, 18], inflammatory markers, or imaging changes as outcome variables [19], and few studies have explored the factors influencing OA from the perspective of survival analyses [20]. However, as patients with knee OA experience often repeated hospital admissions, the resulting readmission data constitutes a form of recurrent event data. Owing to the autocorrelation of the recurrent event data, the classical Cox proportional risk model should not be applied for survival analysis; rather, a frailty model should be used [21]. The frailty model has been used as a common method for dealing with longitudinal data since it was proposed [6, 22]. However, in clinical data, some variables do not satisfy the proportional risk assumption [23]. Therefore, a new model is needed for survival analysis of readmission data from patients with OA that includes time-varying covariates.

Owing to the specific characteristics of knee OA and statistical methods, no definitive reports have described the effect of GCs on the readmission risk in menopausal women with knee OA. Therefore, this study applied a semi-variable coefficient shared Gamma frailty model (VCSGF) to analyze the readmission data of menopausal women with knee OA. By weighing the time-varying effects against the autocorrelation between recurrent events, we focused on the impact of GC use on readmission risk. These finding may guide subsequent chronic disease management in menopausal women and reduce the burdens of disease prevention and control.

Information and methods

Study design and participants

The study was approved by the Ethics Committee of Shanxi Medical University (No. 2015LL067), and informed consent was obtained from all participants and/or their legal guardians. All studies involving human participants were conducted in accordance with the principles of the Declaration of Helsinki.

This study used PASS software for sample size estimation [24, 25]. Based on a knee OA prevalence of 19.1% in Chinese women [26], the power analysis indicated a minimum sample size of 79 for this study, based on a power of 0.8, α of 0.5, and a 20% censoring rate. Thus, this study randomly selected 80 female patients with menopause and knee OA who were treated at a tertiary hospital affiliated with Shanxi Medical University. Follow-up began at the time of discharge after the first admission to the hospital after 1 September 2018, and ends on 31 August 2023. In this study, clinicians appropriately educated the patients to reduce patient loss to follow-up.

Inclusion criteria: (i) meet the American College of Rheumatology criteria for classification of knee osteoarthritis published in 1986 and have the diagnosis confirmed by two orthopedic surgeons with 5 years of experience. (ii) Imaging studies suggest the presence of degenerative changes in the joints. (iii)Participants have not experienced menstruation for 12 months after her last menstrual period and is not pregnant. (iv) Volunteer to participate in the study. Exclusion Criteria: (i) patients younger than 50 years of age in actuality at initial admission; (ii) The patient has a differential diagnosis of rheumatoid arthritis or gout, etc. (iii) The patient has an allergic reaction to GCs or has a contraindication to GC use. (iv) The patient has other serious medical conditions.

Relevant information

Each time a patient was readmitted to the hospital for symptoms of knee OA, clinical data including general information (age, history of smoking, history of alcohol consumption, height, weight), surgical history, GC history, BMI = weight (in kg)/ height^2 (in m^2), uric acid (UA) level, patients readmission, and their readmission intervals were collected. The variable assignments were shown in Table 1. All data were collected by a clinician based on the patient's current admission history. The data were then double-entered by two researchers.

Statistical processing

Statistical description

Data were collated and descripted using Microsoft Excel and R version 4.3.2. Count data are described as number of cases (%), while measurement data with normal distributions are described as $\bar{x} \pm s$. Non-normally distributed measurement data are described as medians with interquartile ranges. Minor instances of missing data were filled using the mice package.

Semi-variable coefficient shared Gamma frailty models

Basic structure of VCSGF The frailty model is an extension of the proportional risk model (Cox model), that incorporates random effects [27]. The model utilises a frailty term to describe the autocorrelation between recurrent events. The shared Gamma frailty model assumes that individuals in the same household or cluster share the same random effects at different time points [28]. Frailty models could reduce the interference with the true effects of covariates due to multiple occurrences of the ending event [29]. In addition, to address the possible problem of time-varying effect covariates, this study introduced time-varying effect terms into the frailty model, constructing the VCSGF as follows:

$$\begin{aligned}\lambda_i(t|X_{ij}, a_i) &= a_i\lambda_0(t)\exp\{\beta(t)X_{ij}^T(t) + \alpha W_{ij}^T(t)\} \\ &= \lambda_0(t)\exp\{\beta(t)X_{ij}^T(t) + \alpha W_{ij}^T(t) + Z_i\}\end{aligned} \tag{1}$$

The shared frailty model [29] can be conceptualized as a multiplicative risk function consisting of three elements: frailty term, baseline risk function, and linear predictor. The VCSGF is built on this by introducing a time-varying effects term $\beta(t)X_{ij}^T(t)$, which quantifies the dynamic effects in the covariates. The new model addresses time-varying effect covariates that cannot be handled by a shared frailty model.

To estimate the time-varying effect terms, existing frailty models with variable coefficients mainly use a spline-based approach [30–32], whereas the present study employed a kernel-smoothing method called local linear regression. Compared with the spline-based method, this method corrects for boundary deviations [33]. This approach is also desirable for the current analysis because early effects (i.e., left border effects) are important, and less clinical attention has been paid to the long-term effects of covariates compared to early effects. Thus, local linear regression is widely used for nonparametric estimation. The time-varying coefficients were estimated as follows:

$$\beta(t) = \gamma_{1l}(t_0) + \gamma_{2l}(t_0)(t - t_0) \tag{2}$$

where $\gamma_{1l}(t_0)$ is a local linear estimate of the intercept $\beta(\cdot)$ at time t_0, and $\gamma_{2l}(t_0)$ is a local linear estimate of the slope of $\beta(\cdot)$ at time t_0.

Gamma distribution An important component of the VCSGF is the frailty distribution, which directly affects the parameter estimation of the model. The common

Table 1 Description of variable assignment

Variables	Variable label	Grouping and assignment
Id	Number of patients with knee OA	serial number
Age	Initial age of recurrence or censoring event	actual survey value (years old)
Smoke	Smoking or not	1 = smoking, 0 = non-smoking
Drink	Drinking or not	1 = drinking, 0 = not drinking
Fat	Overweight or obese (BMI⩾24)	1 = overweight or obese. 0 = not overweight or obese
UA	Uric acid	measured value (μmol/L)
Medicine	Glucocorticoid use or not	1 = yes, 0 = no
Surgery	Surgery or not	1 = yes, 0 = no
Time	Time to recurrence symptoms	measured value (days)
Status	Admission to hospital or not with the symptoms of recurrence	1 = censor, 2 = admission with the symptoms of recurrence

distributions [34–36] for frailty terms include the log-normal, exponential, Gamma, and inverse Gaussian distributions. Among these, the Gamma distribution and the inverse Gaussian distribution have been widely used for modeling, mainly because both are covariate distributions and are included in the model as multiplicative effects [37]. Additionally, the Gamma frailty distribution is easier to compute than the inverse Gaussian distribution, which involves the Bessel function of the second kind [38]. When using the inverse Gaussian distribution, performing parameter estimation is more demanding on the hardware. Although its prediction is more accurate, the results of the two distributions are not drastically different [39]. Therefore, this study considered the Gamma distribution as the frailty distribution for subsequent analysis. The probability density function of the Gamma distribution is expressed as follows:

$$f(a_i) = \frac{1}{\Gamma(\omega)}\theta^{\omega} a_i^{\omega-1} e^{-\theta a_i} \tag{3}$$

Based on the Laplace transformation, and for ease of subsequent interpretation and computation, the Gamma distribution stipulates that $\omega = \theta$, which is equivalent to $\mathrm{E}(a_i) = 1$, when $V(a_i) = \frac{1}{\theta} = \sigma^2$. The frailty term under this approach can be viewed as obeying a one-parameter Gamma distribution, i.e.,$a_i \sim \Gamma\left(\frac{1}{\sigma^2}, \frac{1}{\sigma^2}\right)$. A Larger σ^2 reflects the presence of larger autocorrelations within the groups.

Model applicability conditions As the model used in the present study is an extension of the Cox model, some of the conditions imposed on the Cox model also apply to this model: (1) Sufficient sample size: At least 10 ending events were required for each covariate according to the events per variable (EPV) [40]. However, some studies have indicated that this restriction can be appropriately relaxed [41]. (2) Recurrent events: For the same individual, there exist recurrent events that can be defined. (3) No covariance: The independent variables in the model are relatively independent to avoid a high degree of covariance leading to serious interference in the model estimation. Otherwise, researchers need to consider introducing an interaction term between the two variables into the model. (4) Relative independence: Each individual is independent of others. However, independence between recurrent events in the same individual was not considered. (5) Relatively flexible proportional risk assumption: As the model can address the time-varying effects of covariates, it does not need to strictly satisfy the assumption of equal proportional risk. However, the model still requires this assumption to assist in determining covariates that may have time-varying effects.

Parameter estimation Parameter estimation was performed using R version 4.3.2. A modified expectation-maximization (EM) algorithm was used to estimate the unknown parameters. The baseline distributions used the Weibull distribution and trade-off asymptotic nature. The Weibull distribution is the only distribution that is simultaneously both proportional and accelerated, enabling the estimation of relative event rates and relative extension of survival time, with the latter having significant clinical relevance [42]. To estimate the time-varying effect term, a local partial likelihood estimation constructed using a maximizing kernel smoothing technique based on the Epanechnikov kernel [43] was used in this study.

Results

General information

As multiple recurrent events may have been recorded in the same patient because of the specific nature of repeated measurement data, the patients' baseline information was uniformly used to characterize patients when they first entered the study. The mean patient age at study entry was 64.7 ± 9.3 (range 50–82) years. Of 80 patients, 43 (53.7%) were overweight or obese and 37 (46.3%) were normal-weight. There were no patients who smoked. And Of 80 patients, 3 (3.8%) consumed alcohol and 77 (96.2%) did not. During the research, patients were admitted to the hospital a mean of 2.4 ± 1.8 (range 1–11) times.

Survival curve comparison and proportional risk assumptions

Survival curve comparison

This study used the Kaplan-Meier(K-M) method to compare the occurrence of recurrent symptoms between two or more groups of patients with knee OA and to provide a survival distribution estimate for the time to recurrence in each group of patients with knee OA. The K-M curves differed significantly when patients with knee OA were grouped according to alcohol consumption ($\chi^2 = 15.7, P < 0.0001$, as seen on the Fig. 1), but not according to overweight, medication, or surgical statuses.

Proportional risk assumptions

Table 2 shows the results of the proportional risk assumption. The study found that overweight and medication use did not satisfy the proportional risk assumption ($P < 0.05$), which was considered to have a possible time-varying effect. It was proposed to construct a VCSGF.

The semi-variable coefficient shared Gamma frailty model results

Table 3 shows the final fitting results of the VCSGF, including parameter estimates, standard errors, p-values and hazard ratios [HRs] with 95% confidence intervals

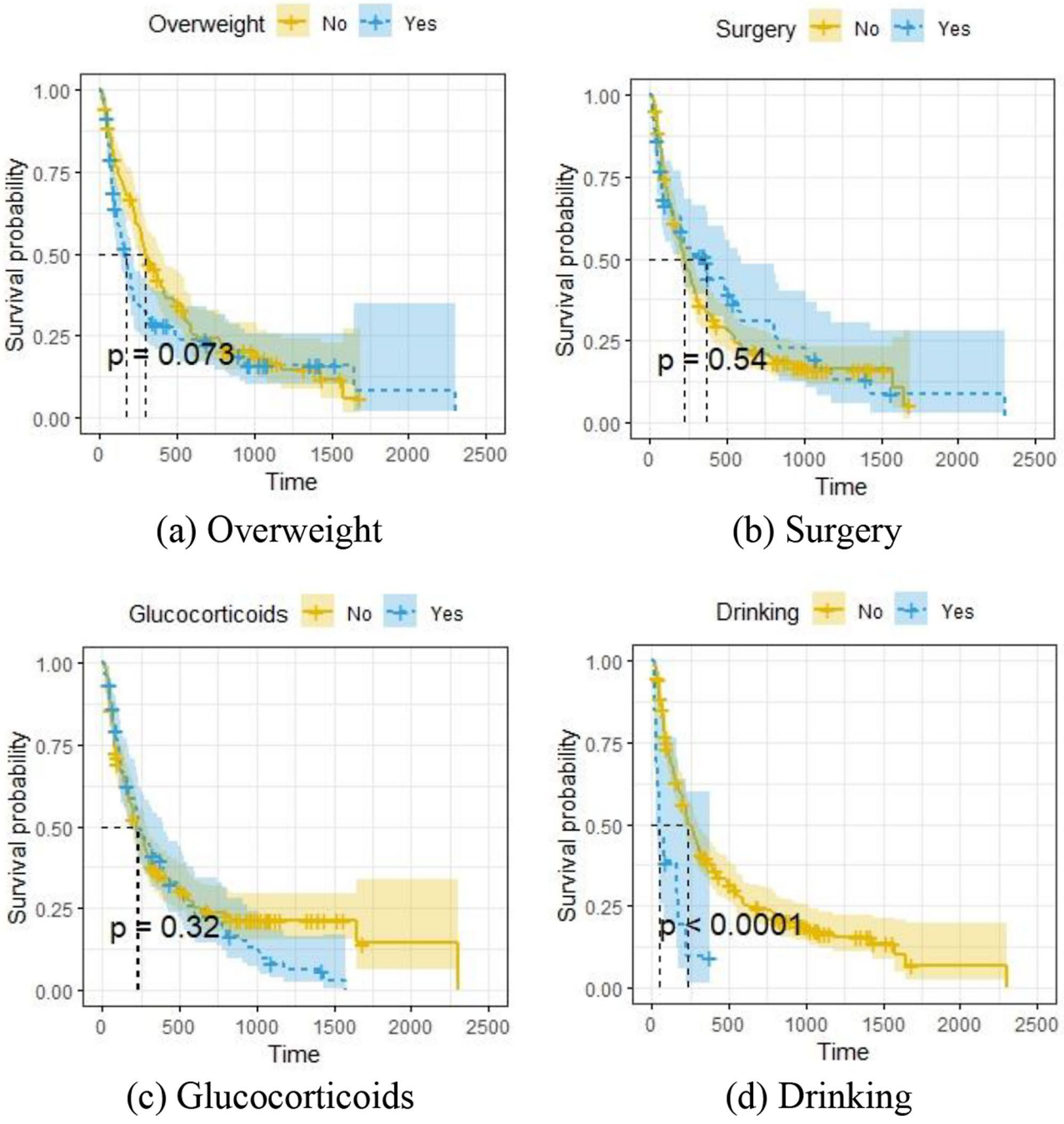

Fig. 1 Kaplan-Meier curves for OA patients with recurrent symptoms for different covariates. Note: Fig. 1 presents the Kaplan-Meier curves for the recurrent symptom risk function among patients with KOA, grouped according to four different covariates. The results showed that the difference in K-M curves was statistically significant only when grouped by alcohol consumption (Log-Rank test: $\chi^2 = 15.7, P < 0.0001$). And the results of the Log-Rank test comparing survival curves among patients grouped by other covariates are presented as follows, with overweight ($\chi^2 = 3.22, P = 0.073$), surgery ($\chi^2 = 0.36, P = 0.544$) and glucocorticoids ($\chi^2 = 0.98, P = 0.321$)

(95%*CI*), respectively. The baseline distributions all used the Weibull distribution. Firstly, overweight and medication use did not satisfy the proportional risk assumption ($P < 0.05$), which was considered in this study to have a possible time-varying effect. Therefore, this study constructed VCSGF. The result showed that only the local linear estimates $\gamma_{1l}(t_0)\gamma_{2l}(t_0)$ for medication use were statistically significant ($P < 0.05$). We considered that the time-varying effect of overweight status could be explained by the autocorrelation of the frailty term. The risk of early readmission in patients who used GCs was reduced by 96% (HR = 0.04, 95%*CI*:

Table 2 Proportional risk assumption results

Variables	χ^2 value	*P* value
Age	0.231	0.631
Fat	5.91	0.015
Drink	2.01	0.156
UA	0.0001	0.992
Medicine	11.0	< 0.001
Surgery	0.434	0.510

Table 3 Fitting results of the semi-variable coefficient shared Gamma frailty model (VCSGF)

Variables	β	se	Wald χ^2	*P* value	HR (95%CI)
Age	0.012	0.008	2.08	0.149	1.012 (0.996, 1.028)
Fat	0.283	0.153	3.41	0.065	1.327 (0.983, 1.791)
Drink	1.21	0.359	11.40	< 0.001	3.353 (1.661, 6.794)
UA	0.0001	0.001	< 0.001	0.921	1.0001 (0.998, 1.002)
Medicine (($\gamma_{1l}(t_0)$)	-3.23	1.01	9.19	0.001	0.040 (0.006, 0.284)
Surgery	-0.186	0.188	0.97	0.324	0.830 (0.574, 1.201)
Medicine (($\gamma_{2l}(t_0)$)	0.629	0.184	11.60	< 0.001	1.876 (1.306, 2.692)
δ	0.0254				
loglikelihood	-899.2				
Loglikelihood ratio test	($\chi^2 = 37.4, p<0.001$)				
AIC	1814.4				
BIC	1833.5				

Notes: $\gamma_{1l}(t_0)$ is a local linear estimate of the intercept of $\beta(\cdot)$ at time *t*0, and $\gamma_{2l}(t_0)$ is a local linear estimate of the slope of $\beta(\cdot)$ at time t_0. δ is the variance component of the fragile term; se denotes the variance ofβ

$0.006 \sim 0.284$, $P < 0.001$) compared to patients who did not use GCs. This protective effect diminished over time ($\gamma_{2l}(t_0) = 0.629, P < 0.001$). Moreover, the risk of hospital admission with recurrent symptoms was approximately 3.35-fold higher in patients who drank alcohol than in patients who did not (HR=3.353, 95%*CI*: 1.661~6.794, $P < 0.001$).

Figure 2 shows the plots of the time-varying effects and cumulative covariate effects of medication use, respectively.

Discussion

Knee OA is a highly disabling degenerative disease that is difficult to achieve eradication clinically. Patients are inevitably admitted to hospitals repeatedly for various clinical symptoms of knee OA; the prevention and control are important. GCs, drugs with anti-inflammatory and analgesic properties, can be used to treat patients with knee OA. However, the management of its use in these patients requires improvement, especially among menopausal women. This is because, as the menopausal process progresses in women, oestrogen production slows down and oestrogen levels gradually decrease, which may directly or indirectly affect the protective effect on the joints. Subsequently, erosion of the articular cartilage surface and inflammatory exudation increased [44]. As erosion progresses the subchondral bone also changes [45]. Additionally, GC use simultaneously accelerates bone loss [46]. Therefore, to better understand the effectiveness of GCs in these patients and improve the management of drug use, the current study employed a novel model to investigate the impact of rational GCs use on the readmission risk in menopausal women with knee OA. Based on our findings, we made recommendations on the use of the drug accordingly.

In this study, the effect of GCs and overweight on readmission of patients with knee OA did not satisfy the proportional risk assumption (Table 2). Therefore, this study built a VCSGF and utilized a kernel-smoothing method (local linear regression) to fit the time-varying effects of both. However, the fitting result indicated that the slope of the time-varying effect of overweight was not statistically significant. We considered that the time-varying effect of overweight was explained by the frailty term, a separate kernel smoothing estimate is not recommended. Therefore, the model was reconstructed by defining overweight as a fixed effect. The results of the new model suggested that GC use reduced the risk of readmission in menopausal women with knee OA and that the effect diminished over time. The results of the kernel smoothing fitting for the time-varying effects were all statistically significant.

Additionally, patients who consumed alcohol showed an increased readmission risk. However, most studies [47, 48] have reported that alcohol consumption to be a protective factor for knee OA, although some studies [49, 50] have found that alcohol consumption increases the risk of knee OA. One thing that these studies have in common is that larger amounts of alcohol were consumed. Small amounts of alcohol are beneficial for people with knee OA, and mandating greater than 1 drink per week can be protective for patients with early-stage knee OA [51]. A more comprehensive description of the amounts of alcohol consumed by the participants in the present study may have resulted in more appropriate results. Additionally, alcohol consumption is associated with many social and medical problems; thus, the results should be interpreted with caution. Therefore, this conclusion should be considered within the wider healthcare context. Second, the findings in the present study regarding the effect of body weight on knee OA were contrary those reported previously. The possible explanations for this discrepancy include: (i)There were more people in

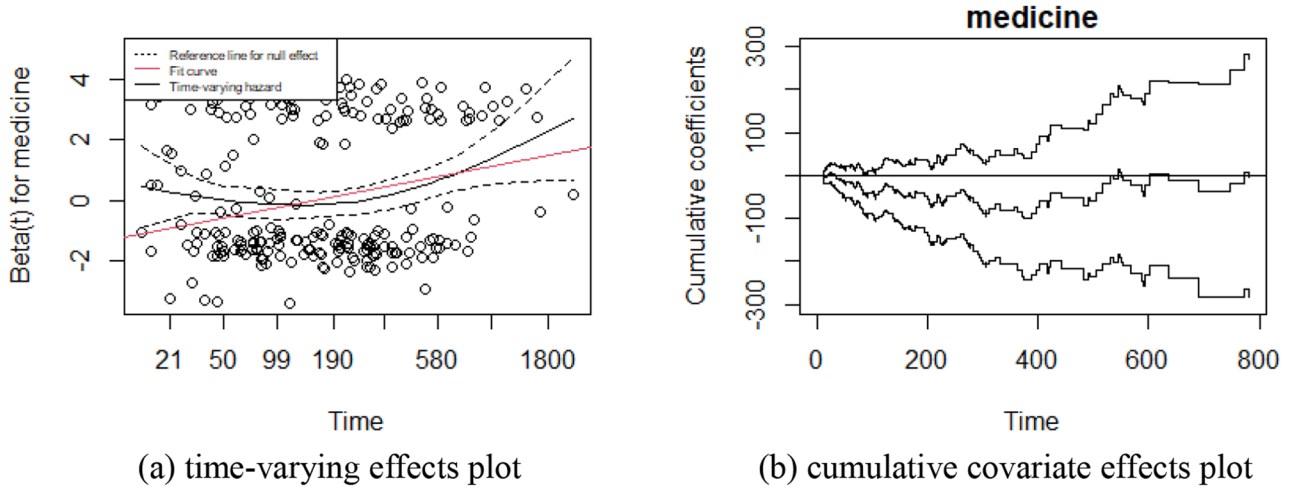

Fig. 2 Plots of time-varying effects and cumulative covariate effects for medication use. Note: (**A**) The red line in Fig. 2(a) was the local linear estimation of fitted time-varying effects by VCSGF. The plots of time-varying effects showed that the local linear estimates were well fitted. (**B**) Fig. 2(b) showed the use of GCs at an early stage could be protective against the admission of patients with recurrent symptoms, which was indicated by the early cumulative covariate effect below the x-axis. However, this protective effect diminished with time and was reflected on the graph as the cumulative effect also moving closer to the x-axis

the study with BMI > 24 but fewer people with the BMI that met the criteria for obesity (BMI ≥ 28), which may have been biased. (ii) The long follow-up of patients and changes in patients' body mass may have also affected the results. The results of this study regarding the increased risk of readmission among overweight menopausal women with knee OA are insufficient to influence the currently established effects of obesity on knee OA.

GCs are used for the treatment of inflammatory, allergic, and autoimmune diseases, and several guidelines now support the short-term efficacy of Intra-articular GC injections (IACS) [52–55]. The pharmacological effects of inhibiting pro-inflammatory factors and chemokines have been widely confirmed. As a degenerative joint disease with inflammatory exudates, knee OA can be effectively relieved by considering the use of GC in patients presenting with acute inflammatory exudates and pain [17]. Moreover, one study [56] has also shown that GC can have a positive effect on the progression of OA from the perspective of inflammatory mechanisms and can be used in the treatment of OA patients. In a double-blind, randomized, placebo-controlled trial using 10 mg/d prednisolone for 6 weeks in patients with hand OA, the researchers demonstrated the effectiveness of prednisolone in improving the signs and symptoms in patients with hand OA [15]. In the present study, considering the repeated admissions of patients with knee OA, a strong autocorrelation was observed between the information in this type of survival data and repeated admissions of the same patient. The results after applying a frailty model to weigh this autocorrelation showed that GC use reduced the risk of readmission by 96% in menopausal women with knee OA (HR = 0.04, 95%*CI*: 0.006 ~ 0.284, $P < 0.001$); however, this effect attenuated over time ($P < 0.001$). The reason for this might be the better anti-inflammatory and pain-relieving effects of the early drugs and the good patient experience. The metabolism of the drug over time and the reduction and failure of the active substance at a later stage may weaken this protective effect. But in short, the use of GCs in menopausal women was effective in reducing the risk of patient readmission. With this effect, the time interval between readmissions was prolonged, suggesting that GC reduces the economic burden of repeated hospital admissions for patients and the disease burden of knee OA on society based on the reduction of pain and inflammatory exudation.

However, there are many limitations in the use of GC, such as adverse effects like osteoporosis, especially for postmenopausal women. Women have lower bone mass, lower bone density, and a higher risk of osteoporosis and fractures than normal individuals [57]. GC use accelerates cartilage loss, causing patients to develop osteoporosis or fractures [46]. Prolonged use of GC is not clinically recommended. Menopausal women using GC should pay special attention to vitamin D, Ca^{2+}, and selenium [58] supplementation to protect their bones. However, there are now also studies [59] that suggest that IACS has fewer short- and long-term effects on cartilage. It may not be clinically important enough to accelerate cartilage degeneration. Therefore, further research is required to explore the appropriate use of GC in patients with knee OA.

This study is still necessary in the current context of knee OA research. The results demonstrated that GC use reduced the risk of readmission in patients with knee OA. This suggested that the rational use of GCs could reduce the disease burden in patients without contraindications.

However, during use, patients are advised to increase supplementation of vitamin such as calcium and vitamin D. Furthermore, the definitions of readmissions and the survival analysis model employed in this study contribute to broadening the scope of subsequent research ideas. It was recommended that future studies could predict the risk of knee OA from the perspectives of survival analysis and recurrent event data analysis.

Despite its insights, it this study also has some limitations. First, there was the limitation of the sample size. And increasing the sample size will lead to more appropriate as well as richer results. In addition, although this study explored the relationship between GC use and the readmission risk in menopausal women, we acknowledged that the impact of the patient's age, actual alcohol consumption, family history, and other interventions were not fully analysed.

Future studies should consider expanding the sample size. This increase will allow exploration of the optimal timing of GC use in menopausal women by grouping participants according to their age or the degree of disease progression. Furthermore, we recommend that future studies integrate the effects of additional covariates. Finally, follow-up studies could be broadened to include the entire female population and male patients or expanded to investigate other joints. Researchers can analyse the effect of GC use on the readmission risk in patients with various OA by constructing the various VCSGF. Such findings could allow a more comprehensive clinical interpretation of the results, refine the guidelines for GC use in patients with OA, and enhance the practical applicability of the findings.

Conclusion

Extrapolated conclusions based on the VCSGF showed that the use of GCs in menopausal women effectively reduced the readmission risk of patients with knee OA, and that this effect diminished over time. This suggests that GC use may reduce the economic burden of repeated hospital admissions for patients and the disease burden of OA on society. Therefore, in such menopausal women without further contraindications, we recommend using GCs appropriately and rationally. In clinical practice, additional research is needed to investigate the timing and appropriate use of GCs in the treatment of menopausal women with knee OA. Develop more rational strategies for the treatment of osteoarthritis and reduce the disease, economic and social burden caused by it.

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Author contributions

HX was a major contributor in writing the manuscript and analyzing data statistically. LHQ and ZRQ collected data from the hospital, organized the data and was responsible for locating references and assisting in analyzing data. ZJF and HHQ analyzed and interpreted the patient data regarding the osteoarthritis (OA) in medicine and explained the study from a clinical perspective. All authors read and approved the final manuscript. HX and HHQ are co-first authors of the article and they contribute equally to the article.

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Data availability

The data underlying this article cannot be shared publicly at this time due to the relevant regulations of the hospital where we got information from. But the data will be shared on reasonable request to the corresponding author.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Shanxi Medical University (ID: 2015LL067). All 80 participants were informed of the details of this study, and every participant provided written informed consent for this study.

Competing interests

The authors declare no competing interests.

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