

Bathing and Toileting Difficulty of Chinese Older Adults: The Role of Environment

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Research article

Keywords: Disability, ADL, Toileting, Bathing, Environment, Older Adults, China

Posted Date: August 24th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-61521/v1>

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Version of Record: A version of this preprint was published on December 10th, 2020. See the published version at <https://doi.org/10.1186/s12877-020-01919-8>.

Abstract

Background: For older adults, difficulties in bathing and toileting are often the most prevalent in the index of Activities of daily living (ADL). Few studies, however, have investigated how the built environment and other environmental factors affect bathing and toileting in later life. This study aims to fill this gap.

Method: The data are from the 2014 Thousand-Village Survey (TVS), a national survey of Chinese rural residents of old age. The sample consists of 10,689 subjects, 55 years or older, from 536 villages across all provinces of China. The multinomial logistic regressions were applied to examine how difficulty in bathing and toileting was related to environmental factors such as geographic location, community amenity, and built environment of bathing and toileting.

Results: Older adults living in the southern regions of China had lesser difficulty in bathing and toileting than those living in Northern China, controlling on other confounders. Better community conditions also reduced the likelihood of having such disabilities. Persons who bathed indoors without shower facilities, in public facility, and outdoors were significantly more likely to have bathing disability than those who showered indoors. Rural older adults who used pedestal pan and indoor bucket for toileting were more likely to have toileting disability than those who used indoor squatting facilities.

Conclusion: Environmental factors are strongly associated with functional disability among older adults, but the relationship is not unidirectional. Having a showering facility could reduce difficulties of bathing for rural Chinese. Very frail older persons may actively choose to change their environmental settings to suit their needs, for instance, by using a pedestal pan or bucket for toileting as an alternative to squatting. There is an urgent need to promote the use of showering facilities and pedestal pans for toileting in rural China.

Background

China currently has around 160 million older adults aged 65 or older, about 11% of her total population, and this number is projected to be about 365 million by 2050, making up more than one-fifth of the world's old-age population aged 65 or older [1]. A direct challenge is thus to meet the huge care needs and demands from the large cohorts of Chinese seniors who may become disabled in later years [2, 3]. Yet, China is less prepared is hardly prepared for this. Although a national social security system is recently in place, the national insurance of long-term care is still developing [4, 5]. State-run old-age care institutions have limited capacity, and the private institutions are still underdeveloped [6]. Also worrisome is the decline of traditional role of the family in caring for older adults given smaller family sizes, many older Chinese will not have any adult children around. Who will take care of disabled Chinese older adults has thus drawn serious attentions in literature [7–9].

Activities of daily living (ADL) are key measures of functional disability for older adults. Six conventional ADLs include feeding, indoor transferring, clothing, toileting, bathing, and continence [10]. ADL disabilities are prevalent among older adults and have severe impacts on health and wellbeing [11–13]. For instance, Purser and colleague (2012) reported that 8.1% of Chinese older adults over 65 years old had at least one ADL disability, whereas this rate increased to 21.8% for oldest olds, namely those over 80 years old. More interestingly, across all ADL items, bathing and toileting stood out to be hardest for seniors to perform in daily life: 18.2% Chinese oldest olds needed assistance in bathing and 8.0% in toileting [14].

The high prevalence rates of bathing and toileting ADL disabilities have been confirmed in numerous other countries such as the United States and the United Kingdom [15–17]. Some studies further reveal that the onset of bathing and toileting difficulties also occur earlier in older adults than other ADL limitations [18, 19]. Specifically, Fong & Feng (2018) showed that older Chinese adults tend to lose ability to use the toilet independently earlier than their American counterparts [20]. Bathing and toileting are more demanding activities than the rest of the ADLs because they involve the complex

movements of both the upper and lower body, whereas other activities are mainly restricted to just either upper or lower body movements [21, 16]. In particular, bathing usually involves bending down, turning around, raising of arms and legs, or gripping with fingers, while toileting involve squatting/sitting, standing up as well as actions of hands and arms [22–24]. Both activities also require good capacities of body coordination, balancing and sensory functions [25].

More importantly, both bathing and toileting are highly embedded in the environment wherein older adults live, and entail interactions between body, facility, infrastructure, climate, temperature and other environmental factors. These activities are often performed in specialized built environments, namely bathrooms and restrooms, being involved with the aid of customized facilities [26]. Thus, disabilities in bathing and toileting could occur due to external barriers or lack of aiding facilities, regardless of intrinsic functional limitations. This is fully in line with the disablement process model, in which both personal and environmental factors could be causes of disability [19]. Along this model, researchers have made efforts to clarify the roles of the intrinsic impairments and external barriers for ADL disability of older adults [27, 28]. And in the new classification scheme of WHO, body impairment and disability have been clearly separated with the latter defined with an emphasis on environmental factors [29, 30].

Few studies have examined the role of environment factors for the two specific ADL limitations in bathing and toileting, although it is well-known that disability in later lives is affected by environmental factors such as geographic locations and community/ neighbourhood condition [31–34]. How the built environment influences these two ADL disabilities, such as the use of pedestal pans for toileting, is an important empirical question. This inquiry is especially timely given the recent Lancet paper by Zeng and colleagues (2017) which revealed that the declining trend in ADL-based disability in China was simultaneously accompanied by an increasing trend in performance-based functional limitations over 1998–2008 [35]. These seemingly self-conflicting trends may be due to significant improvement of the built environment pertinent to the older population during that period of time; however, no empirical research was done so far to address this puzzle.

This study is to fill this gap in literature. We aim to examine how the environmental factors such as geographic locations, community/neighbourhood condition, and the built environment are associated with bathing and toileting difficulties of Chinese older adults. We choose to focus on the rural Chinese in this study, who still have mixed environmental settings in bathing and toileting, unlike their urban counterparts who mostly enjoy standardized modernized environmental settings in these regards [36].

Method

Data

The data came from the 2014 Thousand-Village Survey (TVS 2014), which is a national survey of Chinese villages, administered by Shanghai University of Finance and Economics (SUFU). The survey adopted the multi-stage probability proportional to size (PPS) sampling in order for a national representative sample. Based on the national distribution of rural population per the 2010 census, 31 counties were sampled from 21 provinces of China (representing about 89% of China's total rural population). Then for each county, a town was chosen and for each town, four villages were chosen; in each chosen village, two village groups were finally selected to build up the final sampling frame, from which older adults were randomly sampled. The survey was also implemented by a university-managed fieldwork program, in which rural students of SUFU were asked to randomly sample older adults in their hometown villages and do the interviews using questionnaires of TVS 2014. This program covered all 31 provinces of China. The final sample used in this analysis contain 10,689 valid cases of Chinese rural residents aged 55 years or older, from 536 villages across China. More details of this survey are available in literature [37].

Variables

The TVS 2014 asked respondents reported whether they faced difficulties performing the six ADL activities in daily life. Our study focused on two specific ADLs, namely bathing and toileting, which are most prevalent types among Chinese older adults. These are constructed as separate indicator variables (yes or no).

A number of environmental factors were employed. These included regional-level, neighbourhood-level, and individual-level factors. One variable is geographic location based on the respondent's province (North, Northeast, East, Central-south, Southwest, and Northwest). These regions represented different profiles of temperature and climate as well as socioeconomic development levels in China. To measure the neighbourhood-level environment, we asked the respondents to rate their village in terms of medical service, old-age care service, sanitation, neighbourhood, and security. Each aspect was assessed separately and the response categories include: very satisfied, satisfied, fair, unsatisfied, and very unsatisfied. We generated an index of neighborhood amenity ranging from 0 to 20 by adding up the five items, with a higher score indicating a better condition of the village.

Detailed measures of the built environment specific to bathing and toileting were also included as individual-level factors. These accounted for variation at the individual-level in terms performing these self-care tasks. For bathing, we collated information on how respondents showered on a regular basis. Subjects could select from four different response options including (i) showering indoors, (ii) bathing indoors but no showering, (iii) bathing in public facilities, and (iv) bathing outdoors. Separately, for toileting, the four response options which reflected varied toilet settings included: (i) squatting indoors, (ii) sit-toileting indoors, (iii) using bucket indoors, and (iv) toileting outdoors. These settings reflect the major types of built environment of bathing and toileting in rural China.

We also included a series of demographic, health and socioeconomic covariates that affect ADL disability of older adults as suggested in literature [38–40]. These variables include age, gender, self-reported health (bad, fair, or good), having chronic diseases (yes vs no), economic condition (bad, fair, or good), education (educated or not), occupation (agricultural or non-agricultural). We also accounted for respondents' living arrangement, which has four categories: living alone, living with spouse only, living with children and/or spouse, or living with others.

Statistical Analyses

We applied multinomial logistic regression models to investigate how difficulties of Chinese older adults in bathing and toileting were associated with environmental factors. Within each analysis on bathing and toileting, we also further examined the gender-age-specific results through dividing respondents by gender (men v.s. women) and two age groups (55–74 years old vs. 75 years old and above). STATA 16.0 was used to perform these analyses.

Results

Table 1 describes the sample characteristics. As shown, out of the 10,689 respondents, 7.4% reported difficulty in bathing, while 4.0% reported difficulty in toileting; for the age group over 75 years old, the rates were 16.2% and 7.5%, close to national results of previous literature [14]. As expected, women were more disabled than men in bathing and toileting. It is interesting to note that about 80% Chinese rural seniors bathed indoors, half with showering facilities (about 40%) and half without showering facilities (about 40%). About 15% of them used the public bathing rooms, and very few (about 3%) bathed outdoors. For toileting, about 50% of the rural older adults did indoors, with about 30% squatting and 20% sitting, about 40% of them still used toilets outdoors, and very few (about 4–8%) used bucket indoors for toileting.

Table 1
Description of the sample

	Total	Ages 55–74	Ages 75+	Men	Women
Sample size	10,689	8,261	2,428	5,437	5,252
Difficulty in Bathing (%)	7.4	4.8	16.2	6.6	8.1
Difficulty in Toileting (%)	4.0	2.9	7.5	3.8	4.1
Built environment for bathing (%)					
Showering indoors at home	42.4	44.8	34.2	43.0	41.7
Bathing indoors at home	40.3	37.0	51.5	37.9	42.8
Bathing in public facility	14.4	15.4	11.3	15.5	13.4
Bathing outdoors	2.9	2.9	2.9	3.6	2.2
Built environment for toileting (%)					
Squatting indoors	29.5	29.3	30.2	29.7	29.3
Pedestal pan indoors	24.0	23.5	25.9	23.0	25.1
Bucket indoors	4.4	3.2	8.5	4.2	4.6
Outdoors	42.1	44.1	35.4	43.1	41.1
Neighborhood amenity (mean, SD) (ranges 0–20)	18.8 (3.1)	18.8 (3.1)	18.8 (3.1)	18.8 (3.1)	18.8 (3.1)
Region (%)					
North	10.8	11.8	7.4	10.6	11.0
Northeast	6.0	6.4	4.8	6.0	6.0
East	43.8	42.0	49.8	44.6	43.0
Central South	19.4	19.3	19.7	18.5	20.3
Southwest	15.0	15.0	15.0	15.8	14.2
Northwest	5.0	5.5	3.4	4.6	5.5
Age (mean, SD) (ranges 55–99)	69.0 (7.4)	65.8 (4.5)	79.9 (4.2)	68.9 (7.2)	69.2 (7.6)
Women (%)	49.1	48.6	50.9	0	100
Self-reported health (%)					
Bad	18.6	16.9	24.5	15.4	21.9
Fair	34.5	34.0	36.3	33.4	35.7
Good	46.9	49.1	39.3	51.2	42.4
Having 1 + chronic disease (%)	61.5	61.0	63.2	57.7	65.4
Having 1 + year schooling (%)	65.6	71.3	46.3	79.6	51.1
Economic condition (%)					
Bad	11.0	10.9	11.2	10.5	11.5

	Total	Ages 55–74	Ages 75+	Men	Women
Fair	31.5	31.7	30.8	31.7	31.3
Good	57.5	57.4	58.0	57.9	57.1
Occupation (%)					
Agriculture	80.8	80.3	82.5	73.7	88.2
Non-agriculture	19.2	19.7	17.5	26.3	11.8
Living arrangement (%)					
Live alone	11.7	9.1	20.4	9.9	13.6
Live with spouse only	40.5	43.7	29.9	45.4	35.5
Live with children and/or spouse	45.5	44.9	46.9	42.8	48.1
Live with others	2.4	2.3	2.5	2.0	2.8

Our empirical results revealed strong effects of the built environment on bathing among older adults (Table 2). Both regional- and neighbourhood-level factors were statistically significant at the 0.1% level, controlling on other covariates. Relative to those in North, older adults living in the southern regions of China had less difficulty in bathing. Better community conditions were also associated with less bathing problems, but this pattern seems only applicable for women. Individual-level factors were also statistically significant. Compared with showering indoors at home, the three other settings made bathing more challenging for seniors: specifically, bathing indoors without showering, bathing in public facility and bathing outdoors increased the likelihood of bathing difficulty by 52% ($p < 0.001$), 46% ($p < 0.01$) and 111% ($p < 0.001$), respectively. Not surprisingly, this pattern became more obvious for the older age group, i.e. over 75 years old.

Table 2
Odds ratios for difficulty in bathing

	Both Sexes			Men			Women		
	Total	Ages 55–74	Ages 75+	Total	Ages 55–74	Ages 75+	Total	Ages 55–74	Ages 75+
Built environment for bathing (%)									
Bathing indoors at home (showering indoors at home)	1.52*	1.34 ^{\$}	1.96*	1.62*	1.43 ^{\$}	2.05 [#]	1.49 [#]	1.34	1.90 [#]
Bathing in public facility (showering indoors at home)	1.46 [#]	1.05	2.61*	1.55 ^{\$}	1.27	2.36 [#]	1.48 ^{\$}	0.91	3.33*
Bathing outdoors (showering indoors at home)	2.11*	1.35	3.67*	2.45*	1.65	4.23*	1.83+	1.08	3.44 ^{\$}
Neighborhood amenity [scores 1–25]	0.94*	0.92*	0.96+	0.98	0.95+	1.01	0.91*	0.89*	0.93 ^{\$}
Region									
Northeast (North)	0.99	1.07	0.86	0.82	0.93	0.60	1.14	1.17	1.16
East (North)	0.48*	0.48*	0.47 [#]	0.63 ^{\$}	0.64+	0.53+	0.39*	0.37*	0.41 [#]
Central South (North)	0.38*	0.34*	0.41*	0.51 [#]	0.47 [#]	0.50+	0.30*	0.26*	0.35 [#]
Southwest (North)	0.49*	0.54*	0.40*	0.63 ^{\$}	0.66	0.48+	0.40*	0.43 [#]	0.34 [#]
Northwest (North)	1.08	0.80	2.00 ^{\$}	1.29	1.15	1.77	0.95	0.59	2.49
Age [55–99]	1.09*	1.06*	1.10*	1.08*	1.05 [#]	1.07 [#]	1.11*	1.07*	1.12*
Women (men)	0.89	0.84	1.06	–	–	–	–	–	–
Self-reported health:									
Fair (good)	3.31*	3.57*	3.10*	3.52*	3.90*	3.14*	3.12*	3.19*	3.23*
Bad (good)	8.89*	8.79*	9.53*	9.71*	10.48*	9.34*	8.41*	7.35*	10.71*

Note: *p < 0.001, #p < 0.01, \$p < 0.05, +p < 0.1.

	Both Sexes			Men			Women		
Having 1 + chronic disease (no)	1.42*	1.34 ^{\$}	1.53 [#]	1.40 ^{\$}	1.16	1.79 [#]	1.44 [#]	1.60 ^{\$}	1.29
Having 1 + year schooling (no)	0.79 [#]	0.70*	0.98	0.69 [#]	0.66 ^{\$}	0.72 ⁺	0.87	0.70 ^{\$}	1.39
Economic condition									
Fair (bad)	0.95	0.92	1.03	0.95	0.73	1.74 ⁺	0.95	1.15	0.66
Good (bad)	0.83	0.72 ^{\$}	1.00	0.74 ⁺	0.57 ^{\$}	1.31	0.91	0.87	0.81
Non-agriculture job (agriculture)	1.13	1.22	0.94	1.06	1.13	0.88	1.35	1.48	1.17
Living arrangements									
Live with spouse only (live alone)	1.22	1.10	1.28	1.20	1.06	1.52	1.30	1.18	1.03
Live with children (live alone)	1.90*	1.61 ^{\$}	2.13*	1.94*	1.88 ^{\$}	2.07 ^{\$}	1.89*	1.44	2.19*
Live with others (live alone)	1.32	0.90	1.76	0.82	0.56	1.02	1.80 ⁺	1.15	2.67 ^{\$}
-LL	2237.0*	1352.7*	861.3*	1072.2*	666.5*	393.6*	1151.1*	675.3*	453.0*
# of individuals	10,689	8,261	2,428	5,437	4,245	1,192	5,252	4,016	1,236
Note: *p < 0.001, #p < 0.01, \$p < 0.05, +p < 0.1.									

Table 3 further investigated the role of environment in toileting of Chinese rural older adults. Both regional-level and neighbourhood-level factors were statistically significant, but the effects were weaker than those for toileting. Specifically, the advantage of southern China to northern areas was still existent, and one unit increase in neighbourhood amenity score would decrease the likelihood of toileting difficulty by about 6% ($p < 0.01$). Interestingly, compared to squatting indoors, toileting outdoors led to more difficulty by 60% ($p < 0.01$), the use of pedestal pan indoors had more difficulty by about 2 times ($p < 0.001$), and use of bucket indoors had more difficulty by about 6 times ($p < 0.001$). And such a pattern held mostly across gender and age groups.

Table 3
Odds ratios for difficulty in toileting

	Both Sexes			Men			Women		
	Total	Ages	Ages	Total	Ages	Ages	Total	Ages	Ages
		55-74	75+		55-74	75+		55-74	75+
Built environment for toileting									
Pedestal pan indoors (Squatting indoors)	2.67*	3.00*	2.23#	3.75*	6.03*	2.04+	1.95#	1.62	2.63\$
Bucket indoors (Squatting indoors)	6.69*	5.95*	7.38*	8.26*	9.87*	6.65*	6.05*	4.43*	9.75*
Outdoors (Squatting indoors)	1.60#	1.57\$	1.69\$	1.48	1.76+	1.29	1.79#	1.53	2.44\$
Neighborhood amenity [scores 1-25]	0.94#	0.92#	0.98	0.95+	0.91#	1.02	0.93#	0.93\$	0.94
Region									
Northeast (North)	1.23	1.22	1.27	1.16	1.67	0.42	1.30	0.89	2.86+
East (North)	0.43*	0.41*	0.49\$	0.42#	0.43\$	0.36\$	0.42#	0.36#	0.67
Central South (North)	0.58#	0.50#	0.73	0.47\$	0.34#	0.36	0.67	0.59+	0.97
Southwest (North)	0.84	0.90	0.74	1.05	1.10	0.83	0.65	0.70	0.65
Northwest (North)	0.64	0.61	0.66	0.64	0.75	0.56	0.62	0.52	0.81
Age [55-99]	1.06*	1.05#	1.10*	1.05*	1.04+	1.07+	1.07*	1.06#	1.13*
Women (men)	0.83	0.86	0.78	-	-	-	-	-	-
Self-reported health:									
Fair (good)	2.99*	2.98*	3.10#	3.64*	3.89*	3.57#	2.34#	2.17\$	2.77\$
Bad (good)	11.37*	10.65*	13.35*	16.15*	17.59*	15.94*	7.81*	6.58*	11.88*
Having 1 + chronic disease (no)	1.01	0.91	1.28	1.09	0.83	1.66+	0.98	0.99	1.02
Having 1 + year schooling (no)	0.78\$	0.76+	0.81	0.75	0.83	0.65	0.82	0.72	1.17

Note: *p < 0.001, #p < 0.01, \$p < 0.05, +p < 0.1.

	Both Sexes			Men			Women		
Economic condition									
Fair (bad)	0.75 ^{\$}	0.89	0.55 [#]	0.78	0.67	0.93	0.73	1.16	0.31 [*]
Good (bad)	0.59 [*]	0.59 [#]	0.54 [#]	0.57 [#]	0.51 ^{\$}	0.67	0.60 ^{\$}	0.70	0.43 ^{\$}
Non-agriculture job (agriculture)	1.42 ^{\$}	1.45 ^{\$}	1.34	1.34	1.30	1.36	1.59 ⁺	1.75 ⁺	1.20
Living arrangements									
Live with spouse only (live alone)	1.47 ^{\$}	1.21	1.59	1.26	0.92	1.78	1.60 ⁺	1.54	0.77
Live with children (live alone)	1.80 [*]	1.36	2.33 [*]	1.48	1.30	1.55	2.07 [*]	1.44	3.00 [*]
Live with others (live alone)	1.34	1.19	1.34	0.45	0.36	0.49	2.37 ^{\$}	1.95	3.22
-LL	1416.4 [*]	915.2 [*]	490.5 [*]	674.6 [*]	431.0 [*]	231.9 [*]	729.7 [*]	469.4 [*]	242.0 [*]
# of individuals	10,689	8,261	2,428	5,437	4,245	1,192	5,252	4,016	1,236
Note: *p < 0.001, #p < 0.01, \$p < 0.05, +p < 0.1.									

The results of some covariates are also noteworthy. As expected, younger age, being healthier, and better socioeconomic status were associated with less difficulty of rural older adults in bathing and toileting. Interestingly, living with children was significantly related to bathing and toileting difficulty in later year, as deserves discussion later.

Discussion

Disability is a key measure used by policymakers to estimate care needs among older populations. In various countries, including China, difficulties in bathing and toileting tend to have the higher prevalence rates among older adults than other ADLs. Although these two activities are highly environment-based, there has been less effort in the field to examine how environmental factors, especially built environment, matters in the disabilities of bathing and toileting, though the role of environment is well established for health and well-being of later years [41–44]. Based on the data from the TVS 2014, through examining the difficulties of bathing and toileting of Chinese rural seniors, this paper revealed the significant roles of environment factors in determining ADL disability, such as geographic location, neighbourhood conditions and built environment. To our knowledge, this is the first study on this important topic.

We found significant regional disparities in bathing and toileting limitations among older Chinese adults. This result is consistent with previous studies which have highlighted that ADL disabilities tend to be more prevalent in the Northern region [34]. Since a substantial proportion of older adults in rural China go outdoors for bathing (about 15%) and toileting (about 40%), the climate directly influences their ability to perform these tasks. Another possible explanation for the observed regional patterns is the uneven economic development in China. Eastern and Southern provinces in China

usually have better economies than their northern and western counterparts [45], and older adults in affluent regions may have better resources to cope with barriers of daily life.

This study also confirms that the important role of neighbourhood and community factors in explaining differences in bathing and toileting limitations. A number of recent studies have found that neighbourhood amenities and conditions such as lighting, good traffic, security, sanitation, and public services etc. are positively associated with health and wellbeing of older residents [46–48]. Along this line of work, our study further demonstrated that good neighbourhood amenities also reduced difficulty in bathing and toileting of Chinese rural older adults, for many of whom, these activities are not home-bounded, but in public facilities of the community.

Importantly, we examined in detail the built environment of bathing and toileting for older adults, an aspect that is largely omitted in existing literature. Unlike seniors from developed societies, rural Chinese older adults have various built environment of bathing and toileting. For bathing, showering indoors at home as the modern and convenient way of bathing was only adopted by about 40% of rural seniors. As expected, older people using the other bathing methods encountered more difficulties. They may have to carry additional tasks such as preparing hot water and visiting a place beyond home, deal with unexpected contingencies, and suffer a situation without surveillance of family members [25, 49].

Patterns of toileting use is rather intriguing among older Chinese adults in rural areas. A substantial proportion of these older adults (about 40%) still reported doing toileting outdoors rather than indoors, and about 30% of the sample reported doing toileting by squatting indoors. The remainder, who used bucket indoors and pedestal pan indoors for toileting, reported the most difficulty in toileting. This is somewhat counterintuitive since the bucket and pedestal pan are supposed to make toileting easier. We believe one possible explanation could be that when squatting becomes harder for some frail older adults, devices such as pedestal pan seats and bucket seat toilets are often installed to mitigate the issue and lower the risk of falls [50, 51]. This is consistent with the environmental proactivity hypothesis, that is, older persons in ill health tend to make positive changes to their environment [52, 53]. Therefore, older persons using bucket indoors and pedestal pan indoors for toileting are likely those who in poorer health.

There is good corroborating evidence for this explanation. For example, we observed that the use of bucket and pedestal pan for toileting indeed increased with age (see Table 1). Additionally, compared with solo-living older adults in rural China, those who lived with their adult children were much more likely to experience difficulties in bathing and toileting (see Table 3). Similar to the logic of the environmental proactivity hypothesis, Chinese rural older adults with health declines often chose to live with children for help, as is a norm of old-age care in China [54, 55]. Lastly, how this interesting scenario did not happen for bathing? A partial reason, we think, is that many older adults in rural China may avoid bathing if their health status disallowing, instead of actively seeking for countermeasures. In the additional analysis on bathing in wintertime of Chinese older adults, we found that seniors of poor self-reported health had much less bathing in wintertime than those with good self-reported health. Based on the discussion of both bathing and toileting as above, we propose that the association between environment and disability of old age is not unidirectional, but interactive.

Our findings in this paper confirmed the significant impact of built environment on old-age disability, and thus provided good support for the speculation on the puzzling disability trends of Chinese older adults, as raised by Zeng and colleagues (2017). That is, improvement in facilities and infrastructures of the older adult living environment could effectively reduce their disability, even if their intrinsic functional limitations become worsened [35]. Such a conclusion has important policy implications for societies of population aging. That is, even though the population aging could lower down the general population health, there is always room for us to reverse this negative trend through modifying the built environment towards more age-friendly designs and solutions. For the Chinese rural older adults specifically, this study clearly spotted the urgencies to promote the use of showering facilities and pedestal pans for toileting.

This study also reminds us about the complicity of the disablement process, which is not a purely biomedical issue, but heavily affected by external barriers and facilitators. One direct implication is thus to put caution on the comparability of the routine disability measures such as ADL across nations. Societies with different developmental stages often have diversified contexts for older adults to perform daily activities. Direct comparisons could be misleading, as the results are often mixed with both intrinsic body limitations and external factors. For efforts to clarify these intertwining relations, as suggested by our results, it is also needed to go beyond regional- and neighbourhood-level factors to pay attentions to the built environment.

There are a number of limitations in this study. While we classified a few major types of built environment for toileting and bathing of older adults in rural China, there is surely room of improvement for further research to refine these important measurements. The neighbourhood amenity score is also not an validated index, though with a good face validity by covering major old-age-related characteristics of Chinese rural communities. We thus expect the development of a good measurement scheme for the community environment of older adults in China. Lastly, a part of the sample of TVS 2014 did not come from national PPS sampling, but from the fieldwork of the SUFE students of the rural areas. However, these students came from all of China with quite even chance of being admitted to SUFE, and we thus perceived the sampling bias not to be severe.

List Of Abbreviations

ADL: Activities of daily living

TVS: Thousand-Village Survey

PPS: Probability proportional to size

SUFE: Shanghai University of Finance and Economics

Declarations

Ethics approval and consent to participate

The data from TVS2014 already obtained the ethical approval and informed consent, and was approved by the research ethics committee of Shanghai University of Finance and Economics (SUFE) .

Consent for publication

Not applicable

Availability of data and materials

The dataset is available upon request.

Competing interests

D.G. is a Section Editor at BMC Geriatrics. Q.F. is an Associate Editor at BMC Geriatrics.

Funding

The authors declare that they have no financial support for this study.

Authors' contributions

C.L. collected the data. Q.F., C.L., and Y.D. initiated the study. Q.F., D.G., J.H. analyzed and interpret the data. Q.F., C.L., J.F., J.H., H.W. drafted the paper. D.G., Y.D., H.W., and J.H. provided critical comments.

Disclaimer

Views expressed in this paper are solely those of the authors and do not necessarily reflect the views of Shanghai University of Finance and Economics (SUFE), Jilin University, and National University of Singapore.

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