Energy and Ventilation Use Analysis in Slovenian Elderly Centers

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Abstract: This study investigates energy use and ventilation in elderly care centers across Slovenia, based on questionnaire data. Results show that 44% of the centers rely solely on natural ventilation (opening windows and doors), with no CO_2 meters or recuperation systems installed. The study highlights connections between air quality, well-being, and health. Methods for heating, ventilation, and ensuring air quality were examined, revealing significant gaps in maintaining optimal indoor environments for the elderly residents.

Keywords: indoor air quality, elderly care centers, energy consumption, ventilation

Abbreviations
TSP – Total Suspended Particulate
IAQ – Indoor Air Quality
TC – Thermal Comfort
ECC – Elderly Care Center
TVOC – Total Volatile Organic Compounds
AC – Air Conditioning
PM – Particulate Matter
DHW – Domestic Hot Water

Introduction

Energy use became more challenging during COVID-19, as the need for proper ventilation to prevent infection had to be balanced with minimizing consumption. This article reviews ventilation systems, including their technical aspects, operation, maintenance, and air quality.

Indoor air quality (IAQ) significantly affects health, particularly for elderly residents in care centers, with pollutants like CO_2, CO, NO_2, SO_2, PM, and biological agents (bacteria, fungi, viruses) being key contributors. Migliaretti et al. [1] and Atkinson et al. [2] both found links between urban air pollution and increased hospital visits for respiratory problems, especially among the elderly.

As of 2019, 703 million people globally were 65 or older, a number projected to rise to 1.5 billion by 2050. Slovenia is expected to have one of the highest old-age dependency ratios by then (**Figure 1**).

The GERIA study in Portugal highlighted poor IAQ and thermal comfort (TC) in elderly care centers (ECCs), with concerning levels of CO_2, TVOCs, and bacteria. Simple improvements like insulation could boost health without sacrificing ventilation. In Houston, many assisted living facilities exceeded CO_2 thresholds or were overheated, affecting vulnerable seniors [4].

Research by Fink et al. [5] underscores the sensitivity of elderly individuals with chronic diseases to IAQ

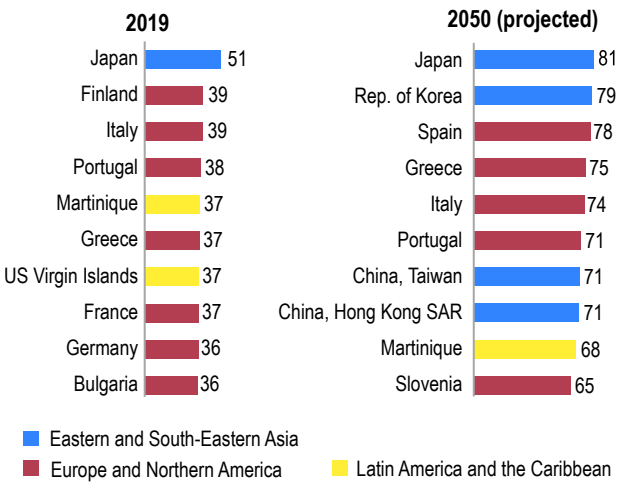

Figure 1. Ten countries or areas with the highest old-age dependency ratio (65+), 2019 and 2050. [3]

and TC, emphasizing the need for well-designed indoor environments. Space heating demand studies [6] showed a base temperature difference in nursing homes, indicating that heating demands could offset some of the benefits of global warming.

Mata et al. [7] recommend a holistic approach to IAQ management in ECCs, focusing on building design, comprehensive IAQ assessments, stakeholder awareness, and automated air-flow systems. These studies underscore the strong connection between IAQ, TC, and health in elderly care settings.

Methods

A comprehensive survey analyzed energy use and ventilation in Slovenian elderly care centers (ECCs). A detailed questionnaire was distributed to approximately 200 ECCs, yielding 16 responses on building energy audits, renovation history, heat consumption, and ventilation practices. The data covered ventilation methods, types of systems used, ventilation frequency, and specific rooms ventilated, focusing on advanced systems like recuperators and CO_2 sensors. Energy consumption data were collected regarding heating and domestic hot water (DHW), compared against 2022 minimum heat consumption requirements.

Standard methods for assessing indoor air quality and energy use were employed, referencing studies such as the GERIA study and work by Satish et al. This approach provided insights into current practices and challenges, integrating energy and air quality considerations in Slovenian ECCs.

Experiment:

Given that people spend around 85-90% of their time indoors [11], minimizing indoor pollutants is essential. Effective practices include selecting low-emission furniture, regularly inspecting ventilation systems, and frequently airing out spaces [8]. The European GERIE study highlights the importance of proper ventilation, demonstrating its independent impact on respiratory health in elderly residents of ECCs [9]. Adverse effects were particularly pronounced in poorly ventilated environments for those over 80.

During the assessment, researchers calculated mean and median values of several air pollutants (e.g., PM10, formaldehyde, NO_2, ozone, CO_2) in each ECC. Only 19% of participants experienced adequate ventilation, and poor ventilation was linked to increased respiratory issues among elderly residents.

Energy use and ventilation:

Space heating accounts for up to 62.8% of final energy in the residential sector [10], with 30-50% lost through ventilation. Given the push for energy efficiency, many new buildings are becoming airtight, leading to reduced air exchange rates (0.2 to 0.3 h^{-1}), below the recommended 0.5 h^{-1} [12]. A review [13] of 20 studies on airtightness and indoor air quality revealed that mechanical ventilation could reduce PM concentrations by about 90% across various sizes, underscoring the need for effective ventilation systems [14].

Research by Satish et al. [15] examined how varying CO_2 concentrations affect human capabilities, involving 22 volunteers performing tasks at different CO_2 levels, as shown in **Figure 2**.

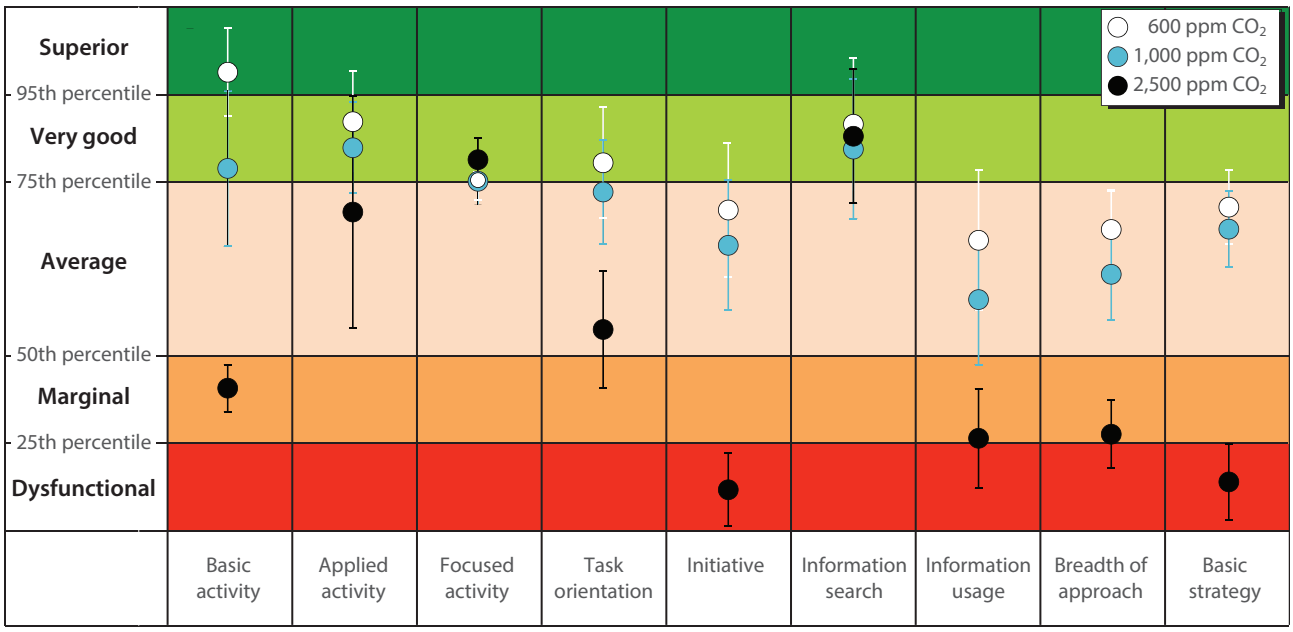

Figure 2. Effect of CO_2 concentration on various activities. [15]

To gather data on energy use and ventilation in Slovenian ECCs, a questionnaire was developed (see **Figure 3**).

Results and discussion

The questionnaire was distributed to approximately 200 ECCs, yielding 16 responses. Most respondents reported having completed an energy audit at least once, with 14 out of 16 confirming this. While many homes had undergone renovations (**Figure 4**), very few had completed energy rehabilitations (**Figure 5**).

Based on the **Figure 6**, we compared the minimum heat consumption requirements for 2022 [16] with actual heat consumption. **Figure 6** shows that most surveyed ECCs are near the required energy consumption levels, although a few exhibit significantly excessive consumption.

We also analyzed whether the data aligns with the aforementioned statistics. **Figure 7** illustrates that annual energy consumption for space heating and domestic hot water (DHW) heating shows space heating typically constitutes the majority of heat needs.

The responses regarding ventilation were limited, but we analyzed the ventilation methods and the rooms that are regularly aired. **Figure 8** illustrates these methods, classified by ventilation quality and color-coded by room. Most ECCs ventilate by opening windows and doors, which is less efficient and less healthy. Some areas use fans, offering better fresh air circulation but still wasting heat. Notably, there was no evidence of recuperators being used, which would be the most energy-efficient option, typically achieving around 95% efficiency while providing adequate fresh air.

It was also noted that no CO_2 sensors were installed. Ideally, ventilation systems should be controlled based on CO_2 concentration, as highlighted in previous studies, since this significantly impacts human activity.

The survey identifies challenges and opportunities in energy use and ventilation among Slovenian ECCs. While most conduct energy audits, only 19% have completed energy rehabilitation, revealing a gap between awareness and action in energy efficiency improvements.

Most ECCs are near the 2022 heat consumption requirements, but some exceed these limits, highlighting the need for targeted interventions. ▶

Questionnaire of basic information about the building

NAME OF THE FACILITY: _____

Contact person	
Phone number	
E-mail address	

Number of employees/users of the building:

	2018	2019	2020	2021
No. of employees				
No. of users				

Basic information about the building:

Is there an energy audit of the building? If yes, please attach it to the questionnaire.	
Year of construction of the building	
Has the building been renovated? When and what measures?	
User area of the building	

Energy use:

Energy source and technology (e.g. biomass boiler, natural gas, LPG, electricity, heat pump...)	
Usage of energy source [l, kWh, m^3...]	
Heating method (radiators, convectors...)	
Temperature regime of the heating system [°C]	
Usage of sanitary hot water [l/day]	
Temperature of sanitary hot water [°C]	
Room cooling method?	

Method of ventilation:

How do you ventilate the spaces (air conditioning systems, opening windows...)?	
Which rooms are ventilated? Are all the rooms for the elderly ventilated?	
What settings do you have on the air conditioning system (temperature, flow, revolutions, schedules)?	
Are there any special microclimate requirements?	
How old are your air conditioning systems?	
How often do you perform ventilation/air conditioning system inspections?	
Do you have a central control system?	
How are your climate systems managed?	
Do you have CO_2 sensors? Are climate systems managed according to them?	
How do you monitor energy use?	
Which rooms are most ventilation critical? Where does the largest number of people stay at the same time?	
How do you ensure adequate indoor air quality?	

Additional comments:

Figure 3. The questionnaire.

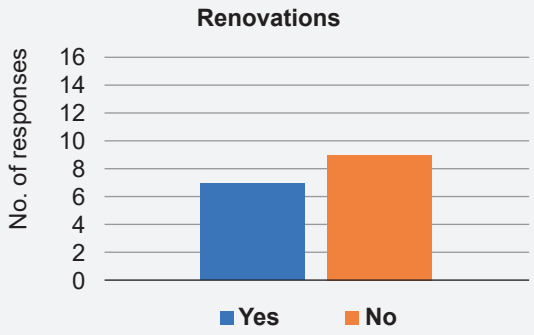

Figure 4. Results regarding renovation in elderly homes.

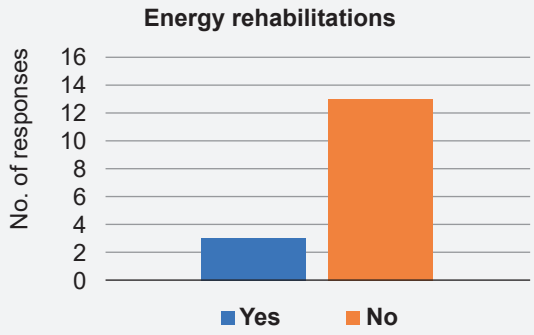

Figure 5. Results regarding energy rehabilitation in elderly homes.

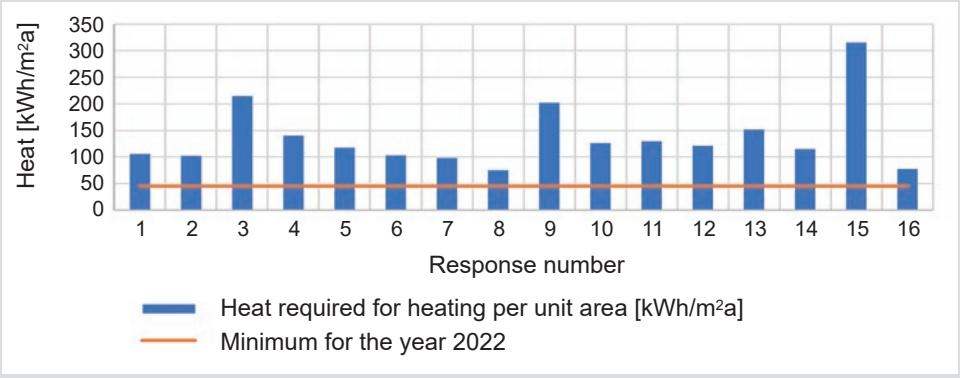

Figure 6. Comparison of heat consumption concerning the minimum.

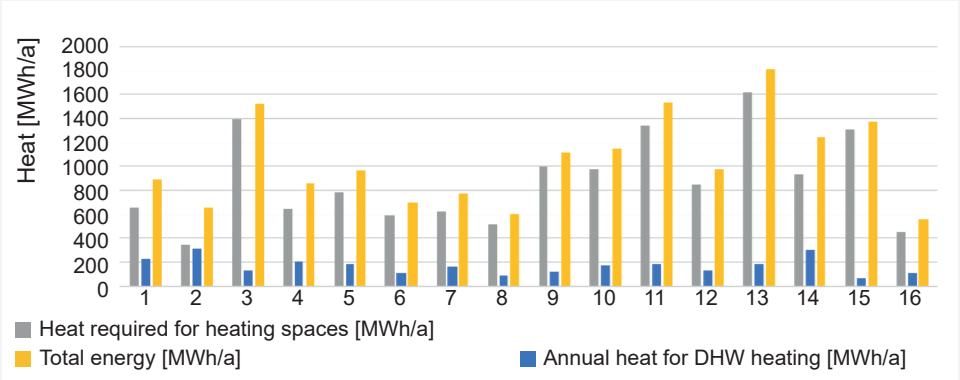

Figure 7. Results of heat needed for heating and domestic hot water.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
residents' rooms	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
residents' bathrooms	1	1	1		1	2	2	1	2		2	2	2		1	1
common spaces	1	1	1		1	2		1			2				3	1
kitchens	2	1	1		1	2	2	2	2		2	2	2		3	
laundries	2	1	1		1	2	2	2	2		2	2	2		3	
staff spaces	2	1	1		1			1			1				1	

1 - window ventilation
2 - fan ventilation
3 - air conditioner

Figure 8. Ventilation methods in different rooms.

▶ Ventilation remains a concern, with many relying on natural methods like opening windows and doors. The absence of advanced systems such as recuperators and CO_2 sensors indicates lost opportunities for energy savings and improved indoor air quality.

Comparing these findings with studies like the GERIA study highlights the ongoing need for effective ventilation to mitigate health risks for elderly residents. Overall, enhanced regulations and practical measures are essential for promoting energy efficiency and better indoor air quality in ECCs.

Conclusion

The questionnaire results indicate that only 19% of ECCs have undergone energy rehabilitation, while 44% have made some renovations. At least six out of 16 ECCs need to address high heat consumption. Notably, 44% rely solely on natural ventilation (opening windows and doors), and 56% use other ventilation methods only in specific areas like kitchens and bathrooms. None of the participating ECCs have recuperation systems, and only one has air conditioning for common areas, kitchens, and laundries, with no CO_2 sensors installed.

To gain a more accurate understanding of energy use and ventilation in ECCs, more data is needed. If our small sample reflects the average ECC, it's crucial to raise awareness among directors about the importance of effective and energy-saving ventilation. Most homes currently ventilate inefficiently, which could be improved by installing more economical systems, like recuperators. However, regulations for residential buildings are lacking, especially for ECCs, which typically accommodate more residents than standard homes.

Monitoring air quality is essential before or after installing ventilation systems, and using CO_2 sensors is a straightforward method. Increased CO_2 levels can also indicate higher pollutant concentrations in the air.

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